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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

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VOL. CVII.—No. 2775.] *LONDON: FRIDAY, MARCH 7, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

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5th March, 1919. T 146

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LONDON COUNTY COUNCIL.

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JAMES BIRD,
Clerk of the London County Council.
T 145

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The Committee of the above Invite

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F. HERBERT TOYNE,
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T. THORP, Secretary.
T 239

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with some years' experience of lorry work; chassis only. Must be acquainted with modern high-production methods and able to advise on types of machines, jigs, &c. After equipment of works, position of responsibility would be made for one possessing the right qualifications. A first-class man is required; no war-time engineers need apply.—Address in confidence, stating experience and salary required, T 173, Offices of ENGINEERING.

Capable Charge Hand Required

for controlling Lifting Tackle, &c., for firm of Constructional Engineers. Must understand the use and overhauling of all descriptions of Cranes, Lifting Tackle, &c. Able to keep own books. Only capable man need apply. State age, wage and experience.—Address, BOX 32, WHEELER'S Advertising Office, Manchester. T 184

Technical Assistant, preferably

with knowledge of electrical engineering, for patent agent's office in London; ability to translate German, or both French and German desirable.—Address, stating age, qualifications, experience and salary required, BOX 745, SELL'S, LTD., 168, Fleet Street, London, E.C. 4. T 181

Wanted, an Engineer, to

superintend engineering shops in connection with large steel works and collieries in south Wales.—Address, stating age, salary required, T 124, Offices of ENGINEERING.

Assistant Engineer

REQUIRED for service in the Public Works Department, Straits Settlements, to prepare quantities, specifications and estimates for, and to supervise the erection of public buildings, roads, bridges and other public works. Engagement for three years with possible extension. Salary £360–£15–£480, with a duty allowance of £75 per annum. Prospects of promotion, if remaining in the service, to higher posts, with salaries ranging between £480 and £1200 per annum. War bonus 15 per cent. of salary and allowance. Free passages.

Candidates, between the ages of 25 and 35, who have passed the A.M.I.C.E. examination or that held by the Institute of Municipal and County Engineers, should apply at once by letter, giving full particulars to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1. T 141

THE MEASUREMENT OF FLUID VELOCITY AND PRESSURE.

By J. R. PANNELL, A.M.I.M.E., F.R.Ae.S.

(*Continued from page* 263.)

"MOVING PART" INSTRUMENTS. CLASS II.

The Robinson Cup Anemometer.—One of the oldest and best known instruments of this class is the Robinson cup anemometer, upon which an exhaustive series of experiments were carried out by Dr. T. R. Robinson in the year 1878.* This anemometer, the original suggestion for which is due to Mr. R. L. Edgeworth, has been very extensively used at meteorological stations to indicate the mean wind speed over stated periods.

This anemometer depends for its action on the integration of the distance travelled by the cups, and a train of gear wheels is usually provided which transmits the motion to pointers moving over graduated dials. The dials read feet, or miles, of air which has passed, but these instruments require calibration at varying speeds, to take account of the change in the factor to connect distance travelled by the cups to actual feet of air which has passed. The theory of the Robinson cup anemometer has been examined in considerable detail by Dr. Chree,† and the following main conclusions are arrived at:—

1. "In steady high winds the ratio wind velocity, divided by cup velocity, is nearly constant; this will not be true at low velocities, however, the error being greater for instruments in which the friction is high.

2. "For winds in which the variations of velocity are large and sudden the mean velocity shown by the instrument is in excess of the true mean. The error is largest when the intervals between the gusts exceed the duration of the gusts."

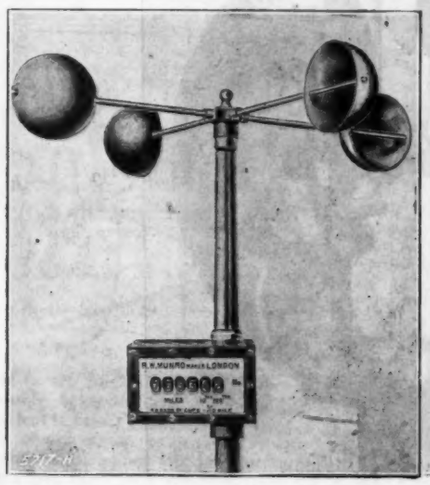


FIG. 8. THE ROBINSON CUP ANEMOMETER.

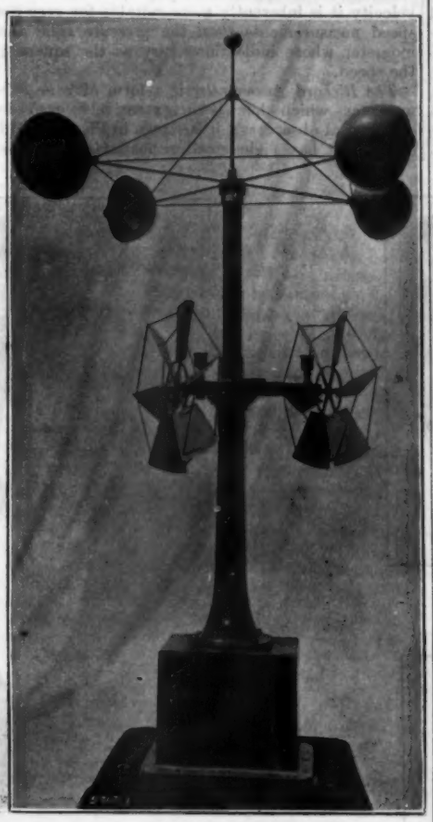


FIG. 9. THE 9-IN. CUP ROBINSON ANEMOMETER.

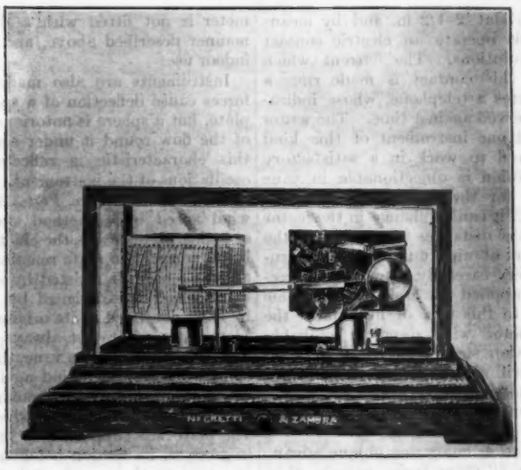


FIG. 10. RECORDING APPARATUS FOR ROBINSON ANEMOMETER.

The form of instrument, shown in Fig. 8, consists of four hemispherical cups carried on light arms attached to a central sleeve which is free to rotate about a vertical axis, the bearings being designed to reduce friction to a minimum. The cups are attached to the arms in such a manner that at the position where motion of the cup is parallel to the wind direction, the concave side of a cup is presented to the wind at the same time as the convex side of the one diametrically opposite to it. The higher resistance of the cup presenting its concave side to the wind causes the cups to rotate when the wind blows, the difference in speed of the cups through the air being such as to compensate for the difference in their resistance. The instrument is thus practically independent of the density of the fluid except to a small extent when friction is present; in a well-made instrument the effect of friction is probably negligible. In the majority of instruments, however, the ratio wind velocity divided by cup velocity is not constant for change of speed, particularly at low speeds, owing to the difference in the variation of force with speed, on the concave and the convex sides of the cups. It has been shown by Mr. E. F. Relf, A.R.C.Sc., that the factors for instruments with cups of different diameters may be compared by plotting on a base of cup velocity times cup diameter, the length of the arms carrying the cups being apparently of secondary importance. The curve is of a shape often met with for such conditions, the slope decreasing towards the higher speeds where the factor tends towards a value of about 2·5. No calibration figures are available for the instrument with 9-in. cups, shown in Fig. 9, but it appears that the variation of the factor with speed would be appreciably less than for instruments with 3-in. cups, for which the factor changes about 20 per cent. over a range of speed from 20 ft./sec. to 50 ft./sec. This instrument is of the distant-reading type referred to below. The pair of vane wheels seen in Fig. 9 indicate the direction of the wind in a horizontal plane.

The most important points to be attended to in the manufacture of Robinson cup anemometers are, low friction, light moving parts, and reasonably large cups.

Instruments of this type are also constructed in which the indicating mechanism is placed at any convenient distance from the cups, an electric circuit being made after a predetermined number of revolutions of the cups. The electric current energises an electro magnet which moves forward the pointers by an appropriate amount.

If a continuous record of the velocity is required the *Lownes patent recorder*, shown in Fig. 10, can be used. The drum is rotated by clockwork while the pen moves vertically at a rate depending on the speed of the wind. The form of record which is obtained can be seen on the chart in the figure to consist of a number of inclined lines to the slope of which the wind speed is proportional. The vertical motion of the pen depends on the rotation of a helical cam actuated through a chain of gear wheels by an electro magnet which receives an impulse when the circuit is closed by the rotation of the cups. The contacts are arranged in a chamber at the base of the Robinson cup standard (as in Fig. 9), and are geared to the cups in such a manner that an impulse is imparted to the magnet after each nominal 1/10th mile. The maximum travel of the pen is 100 miles and the cam is cut down sharply to allow the pen to return, under the action of a dash pot, to the bottom of the chart where it commences a new curve. A feature of the arrangement is the device which ensures that the time of contact shall be approximately independent of speed of the cups, thus preventing the battery being run down at low speeds.

An electrical instrument made by Messrs. Elliott Bros. was in use at one time in which an electric current was generated by the rotation of the cups. This current operated an Elliott recorder giving a continuous record of the speed at which the cups rotated; the recorder could be placed at a considerable distance from the cups.

The Vane Anemometer is another instrument which has been very extensively used. It is more portable than the cup type and is often employed for measuring air velocities at the outlet of pipes, in mines, and on many occasions where the instrument is not exposed to the action of the weather and the speed is not too high. These anemometers are not suitable for use in natural winds as the parts are comparatively delicate and can hardly be protected as efficiently as in the Robinson cup type; also vane instruments are rarely used above about 50 ft./sec.

A very common type of this instrument is shown in Fig. 11, where a wheel carrying eight vanes drives a pointer which moves over the large dial graduated in feet up to 100. In addition there are five small

* Phil. Trans., Royal Society, 1878.
† *Phil. Mag.*, July, 1895, page 63.

dials by means of which the instrument records up to 10,000,000 ft., the velocity being determined by observing the instrument reading against time. An alternative design is that in which the dials are placed with the centre of the arrangement coincident with the axis about which the vanes rotate and the plane of the dials normal to the wind direction. This latter type of instrument is very compact and is admittedly of more attractive appearance than the one shown in the figure but it has, in the author's opinion, the disadvantage that the observer is likely to stand in such a position that he constitutes an obstruction to the current whose velocity is to be determined. The error due to this cause may under certain circumstances be considerable, and it should be noted that an obstruction is not rendered inoperative by the fact that it is located in the air *after* it leaves the anemometer. In using instruments which are supported by the observer during the test, great care should be taken to hold the instrument in such a manner that there is an unobstructed stream flowing past it. A very sensitive anemometer of this type was constructed at the National Physical Laboratory* for measurement of the motion of the air in the shed which houses the whirling arm. The instrument had four vanes set at 30 deg. to the wind direction, and carried on arms from a spindle turning in jewel bearings. The diameter was 4 in. and the friction of the bearings was so low that the instrument could be satisfactorily used at velocities of less than 0·5 ft./sec. Gearing was entirely eliminated, the revolutions being counted by means of electric signals which were sent when contacts on the vanes passed through bubbles of mercury. A telephone receiver was found to be a convenient instrument for observing the number of contacts in a given time.

It may be noted that since the motion of a vane anemometer is approximately proportional to the velocity it is inherently more suitable for very low speed measurements than the pressure tube anemometer whose indications vary as the square of the speed.

The Richard Anemometer is a form of vane anemometer which has been extensively used by continental observers; it is shown in Fig. 12. This instrument has eight small vanes which rotate at a radius of about 2–1/2 in. and by means of gear wheels operate an electric contact every 28 revolutions. The current which passes when this contact is made rings a bell, or operates a telephone, whose indications are observed against time. The writer has examined one instrument of this kind which appeared to work in a satisfactory manner. Friction is objectionable in vane anemometers for the same reason as in the cup type, viz., it causes change in the factor which converts distances travelled by the vanes into feet of air; unless these instruments are very carefully made the corrections to be applied at low speeds become very large. In this type of instrument the variation in the factor with speed is probably entirely due to friction since in a frictionless instrument the vanes will rotate at such a speed that the relative wind is tangential to them.

This type of instrument will be referred to again later in the section on "Ships Logs."

Pendulum Anemometers enjoy one unique advantage over practically all other types, namely, they give an instantaneous indication of the wind speed as determined by the pressure exerted on a solid body and, since the only quantity to be observed is the displacement of the pendulum, are entirely self contained.

The revised edition of the "Directions to Seamen," published in 1667, contained a description of an anemometer of this type in which a plate hanging on an arm in the manner of a pendulum was deflected by the force of the wind. The movement was measured on a graduated quadrant which, with the swinging plate, could turn freely as a vane about a vertical axis. This anemometer has been attributed to Dr. Hooke, who edited this edition of the "Directions to Seamen," though it appears to have been in use at a still earlier date; it constitutes the earliest record of an anemometer with which the writer is acquainted.

An instrument of this kind, supplied by Messrs. A. W. Gamage, Limited, is shown in Fig. 13, fitted with a degree scale for purposes of calibration. The swinging plate is hung on knife edges and loaded near its centre by a detachable weight. When in use the instrument is fixed to a rigid support and adjusted to the zero position by means of the spirit level which is provided. The plate is displaced until the restoring force is equal to the wind force on the plate; the instrument is reasonably free from oscillations in a steady current. This anemometer is not fitted with a direction vane in the manner described above, and is only intended for indoor use.

Instruments are also made in which the wind forces cause deflection of a sphere instead of a flat plate, but a sphere is notorious for the unsteadiness of the flow round it under certain conditions, and this characteristic is reflected in the increased oscillations of the instrument.

The Osler Pressure Plate Anemometer measures wind speed by a method similar to that of the swinging plate device, the chief difference being that in the former the plate remains normal to the wind and its motion is resisted by springs. This instrument which was designed by Mr. A. Follett Osler in 1836, consisted in its original form of a pressure plate 1 ft. square set always normal to the wind direction by means of a vane, the plate moving under the pressure of the wind against spiral springs of which one, two or three came into action depending on the distances through which the plate moved. The plate was supported by horizontal rods sliding in grooves, its motion being transmitted by means of a cord to the pencil of the reading mechanism. This consisted of a strip of paper moved by a clockwork driven drum upon which a trace was drawn by vertical motion of the pencil. The pressure plate mechanism was modified in 1866 by Mr. Browning, and as far as the writer is aware, is in use in this form at the present time at Greenwich Observatory. The changes were chiefly in the direction of reducing friction; the vane shaft was fitted with an improved form of bearing and the mechanism controlling the motion of the plate under the wind forces was modified in the manner described below.

The rods sliding in grooves are eliminated in Mr. Browning's arrangement, shown in Fig. 14, the plate being hung on a system of flat springs which

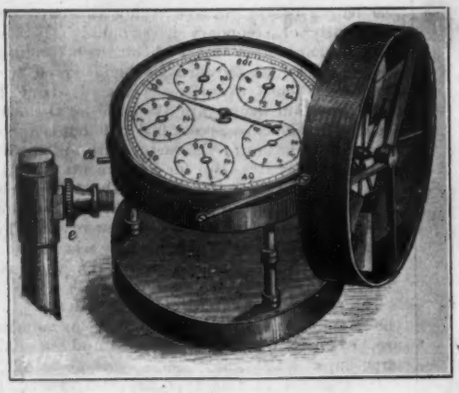


FIG. 11. THE 8-VANE ANEMOMETER.

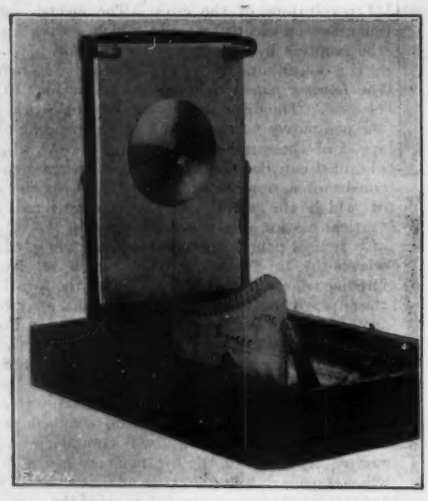


FIG. 13. THE SWINGING PLATE ANEMOMETER.

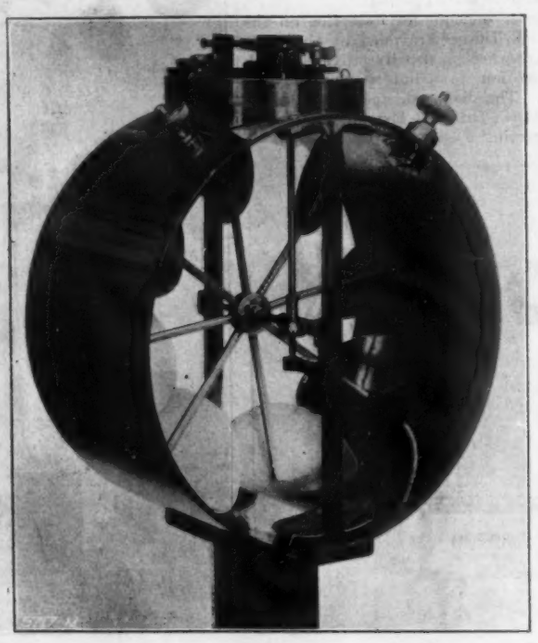


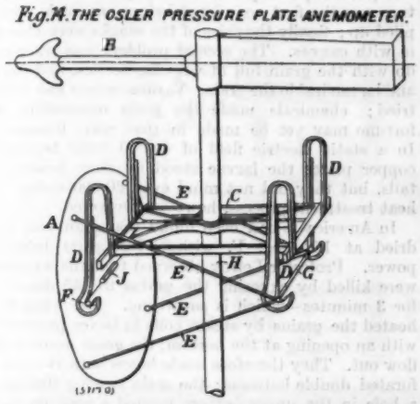
FIG. 12. THE RICHARD ANEMOMETER.

* Report, Advisory Committee for Aeronautics, 1912–13, page 36.

are deflected by the force of the wind on the plate. The springs are of two strengths and the strong ones, D, are carried on a rectangular frame, C, attached to the vane shaft H; to the strong springs are attached four light ones, F, one pair of which are fastened to the light rods E. These rods are connected to the pressure plates near its circumference, a further connection J being made near the centre of the plate to a rod borne by the other pair of light springs.

For low wind forces the four weak springs oppose the motion, but the ends of one pair soon come into contact with the ends of the strong springs to which they are attached, the sensitivity being thereby reduced; further movement causes the ends of the second pair of weak springs to come into contact with the strong ones and motion is then opposed by the four strong springs. By this means considerable sensitivity (the instrument is said to record less than 1/10th lb.) is obtained at low pressures, coupled with a wide range. The movement of the plate is transmitted to the recorder by mechanism

Fig. 14. THE OSLER PRESSURE PLATE ANEMOMETER.



similar to the original, the only other change of importance being the use of a circular plate two square feet in area.

It is remarked that the pressures recorded appear to be greater per square foot than formerly, a result which might have been expected from the known increase of the coefficient in the pressure equation as the size of the plate is increased.

*The Bridled Anemometer.**—This instrument was designed about 1880 by Sir G. G. Stokes, F.R.S. It consisted of a number of cups similar to those used on the Robinson cup instrument, distributed round a vertical spindle in such a manner as to render the instrument approximately independent of wind direction in a horizontal plane. The pressure on the cups caused the spindle to rotate and raise two weights in the chamber below. The cords to which these weights were attached operated over cams intended to be shaped in such a manner that the record obtained on a drum operated by clockwork had a uniform scale of velocity.

The weights were sufficiently heavy to prevent the cups making a complete turn during the strongest gusts, a measure of which it was particularly desired to obtain.

(To be continued.)

LIGNITE IN GERMANY.—The Union of the German Lignite Industry states that during the first month of the present year it was not nearly possible to satisfy the demand for all kinds of lignite products. The main reason is the reduced production. The shortage of locomotives has in some isolated instances interfered with deliveries, but has never led to stoppage of work at the mines or works, and only in odd places to storing lignite and briquettes. The production of the individual works generally remains at the same low level as in December, 1918, and is far below that of the corresponding month of last year. The production is particularly low in the Halle district. On the whole, shortage of labour is a thing of the past, with the exception of the Lausitz district, and there is in many places even a surplus of labour, but putting in a number of unskilled hands, although it swells the list of employees, does not correspondingly increase the production, and the men almost everywhere decline to work overtime beyond the 8 hours. There have been some strikes and stoppage of work, partly from wage questions but mostly from political motives.

* Report, Meteorological Council, 1898, page 29.

CLOCK ESCAPEMENTS.

WITH the aid of many working models, Mr. A. T. Hare, M.A., succeeded on Friday, February 21, in making the intricate subject of "Clock Escapements" interesting to the Royal Institution. It is the escapement and its combination with the pendulum which have rendered accurate time measurement possible in modern ages. We know very little about the construction of the sun dials of the Babylonians and of the Book of Kings which, though free from instrumental errors, could only be used when there was a sun to cast a shadow, and the water-clocks (water-thief clepsydra) and sand-clocks of later days did not admit of high accuracy, though water-clocks such as Caliph Harun-al-Rashid sent to Charlemagne in 801 were remarkable works of art.

The escapement belongs to a later period. One of the earliest escapement clocks, the historical iron clock of Dover Castle (now in South Kensington Museum) Mr. Hare had—he stated in his discourse—seen at Dover as a child. That clock, of Swiss make, was brought over to England in 1348, probably for Edward III. The escapement was of the "verge" type. A horizontal arbor, turned by a train and weight, carried a "contrate" wheel, really a cylindrical ring with a serrated edge of long, slanting teeth. In front of the wheel was a vertical spindle (the verge), a rod of T shape, the horizontal bar of which supported two weights, the "balance," to which clocks of this type owe their name balance (waag) clocks. From the stem of the T projected two pallets, the one engaging with a tooth in the upper part of the wheel, stopping the wheel, while the pallet lower down allowed a tooth in the lower portion to slip; thus angular momentum was imparted to the balance, and its oscillating movement reversed. In order to reduce friction the verge was suspended by a string; but the rate of the clock, Mr. Hare pointed out, depended entirely upon the force of the train, and he doubted whether such a clock would keep correct time within less than 20 minutes a day. The clocks, with which the Emperor Charles V is said to have experimented after abdicating in 1556, were probably of this type; little wonder that he found the task of regulating clocks as hopeless almost as his endeavours to rule peoples of different races and religions. For clocks were only fitted with pendulums by Huygens in 1657, though Galilei had studied the law of pendulum isochronism sixty years previous, and simple pendulums (lead balls suspended by cords) had long been used for measuring short intervals of time. Huygens is also credited with having replaced the bristles of the early pocket watches (Nürnberg eggs), which had come into fashion about 1500, by the helical hair spring of the balance.

To Huygens is further due the improvement of the pendulum clock by means of the cycloid. Mr. Hare referred first to this point in his remarks upon the pendulum theory. The cycloid was peculiar geometrically with respect to its evolute and involute and had the unique mechanical property that a body falling from any point on a cycloid would reach the bottom of the arc in the same time, no matter how high up the starting point was on the arc. Huygens hence made the upper part of his pendulum rod flexible and set it between two pieces of brass of cycloid shape, thus obliging the bob to trace an involute; the pendulum period should then be independent of arc of swing. But the silk thread by which he suspended the rod was too much influenced by the weather. The cycloid was therefore given up and the pendulum allowed to swing in a circular arc, the rod being suspended either by a knife edge or by a short piece of thin spring. The disadvantage of the knife edge was that it was only suitable for pendulums of small weight, otherwise objectionable, and the spring changed its length with the temperature; the spring had prevailed, however, though in old clocks silk threads were still to be found. The greater the arc of swing, the greater was the time occupied by an oscillation, and hence also the time lost by a pendulum clock; if for some reason the semi-arc of a pendulum should increase from 2·5 deg. to 3 deg., the pendulum would lose 4·5 seconds per day; if the increase were from 4·5 to 5 deg., the loss would amount to 7·8 seconds. The arc should therefore be kept small, though not too small, about 2 deg. or 3 deg. on each side of the vertical. These considerations held strictly only for a free pendulum, however; a good escapement would mask this defect. On the other hand the friction of the suspension and the resistance of the air had to be overcome in clocks, and as constant a driving power, "maintenance," as possible had to be provided.

The adaptation of the verge escapement to the pendulum, Mr. Hare continued, had not caused difficulty. If we turned the Dover model on one side and removed one arm of the balance, we had the germ of the pendulum-clock, and that, in fact, was the course which the horological evolution had taken. There were many objections to the old verge, however. The pendulum was not free except for the moment when the impulse passed from one pallet to the other, and the whole device would only work properly with a large arc of swing which was undesirable. In order to reduce the arc, Huygens made the verge the axis, not of the pendulum crutch, but of a small pinion gearing with a large wheel on the crutch arbor; but his arbor remained under the "dominion" of the train. The "anchor or recoil" escapement soon superseded various other improved devices; it was an English invention of 1675, though a fierce controversy sprang up as to the rival claimants, Hooke (of Hooke's law and joint), and W. Clement, a London clockmaker. Still used in nine ordinary clocks out of ten, the anchor escapement was surprisingly good with a compensated pendulum, but not suited for turret clocks and high-quality regulators. The recoil restrained the variation of the arc without a corresponding increase of accurate timekeeping. Then George Graham, 1715, a pupil of Tompion (both buried in Westminster Abbey), removed, in his "dead beat" escapement, a portion of the flukes of the anchor, dividing the acting surface into two parts, the one to lock the escapement without exerting any force (except friction) on the pendulum, the other to give the impulse. For indoor clocks this escapement was still considered unsurpassed by some authorities; for turret clocks, which owing to the wear and to the action of wind, rain and snow on the exposed hands, and the clogging of the oil, were subject to strong variations in the train force, escapements directly driven by the train were not recommendable. The "duplex" escapement, ascribed to Hooke and to Thomas Tyrer, shared this drawback with many advantages; the duplex model which Mr. Hare showed had been made in the Royal Institution by Thomas Young. The wheel of this device had five long teeth to lock the escapement, and five small teeth nearer the axis to give an impulse to the pendulum at every second swing; a duplex escapement clock of Lord Grimthorpe's kept good time for eight years even without oiling, the lecturer mentioned.

Meanwhile the "remontoir" principle—again due to Huygens—had found more general recognition, viz., that the train should not drive the pendulum, but should merely record the number of revolutions and keep a weight lifted or a spring wound up. The pendulum had still to unlock this device, however, and was subject to residual friction not independent of the train, until A. Cumming, in 1716, relifted the pallets and let them fall by gravity on the pendulum. This "gravity escapement" was greatly improved by Thomas Mudge so as to avoid "tripping." The trouble was that considerable power was required, especially in turret clocks, since each tooth had to lift the gravity-piece by sliding along an inclined plane; the gravity-piece might then acquire sufficient momentum to allow several teeth (instead of one tooth) to get clear, and such tripping would, of course, altogether stop good timekeeping. But there remained the possibility of the "approximate tripping," of Lord Grimthorpe, the holding of a tooth, which would enlarge the arc of swing; that, Mr. Hare thought, might have been cured by a dash pot or wind-fly. The long locking arms and short lifting arms of Bloxam gave a beautiful solution of this problem, but his escapement had to be well made.

Passing to turret clocks in particular, Mr. Hare

mentioned that the building of the Clock Tower for the Houses of Parliament had afforded a favourable opportunity, ample time, and also funds for the design and contruction of a first-rate piece of mechanism by Mr. Denision (afterwards Lord Grimthorpe) and Mr. A. J. Dent. In a period of ten years two escapements were tried and rejected in favour of a modification of Bloxam's device, which Mr. Hare described in detail. As the Denison escapement was not quite free of friction, however, it was, in the clock of the Royal Court of Justice, built twenty years later, combined with a remontoir train.

Mr. Hare next explained how he himself eliminated pivot and other friction by combining the devices of Vérité and of Kater. Vérité (of Beauvais) had an escape wheel of 30 pins; one pin was gripped by the arms of a rocking lever, the other end of which was tilted by the pendulum. When the tail of another lever, on the other side of the wheel, allowed a pin to pass, it lifted a little ball suspended by a silk thread; the ball remained in contact with its saucer-shaped pillar, however. The novelty in Captain Henry Kater's device was the "inertia piece." The gravity arms of the usual shape did not themselves lock the teeth of the escape wheel; through each gravity piece passed a set screw, always bearing against a mass of metal of the shape of a gable roof; this roof, pivoted at its centre of gravity, rested indifferently in any position and moving sluggishly, unlocked the pendulum when out of contact with the gravity piece. The characteristic parts of Mr. Hare's device are illustrated in Figs. 1 and 2. In Fig. 1 F is part of the left arm of

Fig. 1.

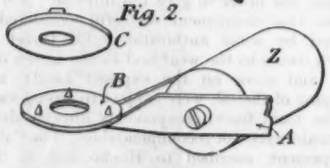


Fig. 2.

a nickel steel bar mounted on the top of the pendulum; into the plate at the end of F is screwed the vertical stem H, which is headed by a small spherical ball. On the other side of the pendulum would be the right arm of F, and a corresponding stem H. The ball and stem pass without touching through the circular opening in the disc B, which is supported by the end of the rocker arm A; this arm is weighted by the lead cylinder Z and forms the inertia piece of the device. A little weight shaped like a Puritan's hat, C, Fig. 2, rests either on the ball (as on the head of the wearer) or by its broad brim on the three small studs projecting upwards from the rocker plate B; the object of the points is to minimise the surface on which dust might lodge. The whole arrangement is duplicated on the right side of the pendulum. When the clock is at rest, the pendulum is vertical, the rocker A lies horizontal, and the stems are so adjusted that the small weights C rest indifferently on the balls and on the plates. When, now, the pendulum is pushed to the right—as Mr. Hare explained with the aid of a model—the right-hand weight C is lifted of its plate B, while the left-hand C is left behind on its plate. That upset the balance of the rocker A, which tilted a little to the left, unlocking the escapement; the latter turning caused a camplate to revolve through a small angle and, by means of one or two arms carrying anti-friction wheels at their ends, moved the rocker into such a position that the right-hand B (from which the C had been removed) was slightly depressed. At the next swing of the pendulum the pendulum then deposited this weight on the plate at a rather lower level than that at which it had taken the B up. The rocker did all the work, leaving the pendulum free from connection with other parts of the clock; the pendulum picked the little weights up and set them down again without any friction.

Concluding, Mr. Hare referred to the series of papers which Professor R. A. Sampson, the Astronomer Royal for Scotland, has been contributing to the Proceedings of the Royal Society of Edinburgh on his experiments with three clocks, models of which Mr. Hare exhibited. The escapement of the first clock, by Mr. Cottingham, was a modification of Sir David Gill's device: the pendulum was driven by a gravity piece which by its contact with the pendulum completed the circuit of an electromagnet, the armature of which served as stop for the gravity piece. The second escapement by Riefler, of Munich, differed from those so far described; the energy was communicated to the pendulum by bending the suspension; the peculiarity was that the block from which the suspension was hanging was not immovably fixed, but supported on knife edges, and rocked on them so as to unlock the escape wheel, bending the spring back against the motion of the pendulum. In the third escapement of the Synchronome Company the action took place at the bottom (not at the top) of the pendulum.

The perfect clock, Mr. Hare finally remarked, would have to be a pendulum clock, the pendulum being of invariable moment of inertia and acted upon by invariable forces. Though those conditions were not yet fulfilled, temperature changes could be compensated for by the gridiron pendulum of Harrison, by the zinc-iron combination of turret clocks, by the expansion of mercury in the bob (Graham), or by the use of nickel steel, or also by enclosing the whole clock in a thermostatic chamber, as Sampson did. The invariability of the forces was much more difficult to obtain. There were, besides the inevitable friction of the escapement, the buoyancy of the air, which could be minimised by keeping a constant reduced pressure in the glass case, and the troubles connected with the maintenance and recording. Yet perfection was being approached asymptotically. With the Riefler, Cottingham and Synchronome clocks, mounted in his thermostatic chamber and barostatic cases, Professor Sampson had observed errors not exceeding on average 0.01 second a day, that is to say, at the rate of 1 minute in 16 years—if the clocks could run so long without stopping. That, it will be conceded, is an almost miraculous accuracy unrivalled in any physical measurements.

FIGHTING INSECT FOOD PESTS.

Lecturing upon "Insect Enemies of our Food Supplies" at the Royal Institution last week, Mr. H. Maxwell Lefroy, M.A., Professor of Entomology at the Imperial College of Science, S.W., remarked that after all a great deal of entomology was simply common sense. We feel inclined to add that the fight against insect pests finally turns into a problem for the engineer. Professor Lefroy first dealt with locusts, and especially with one kind of locusts which invaded a large portion of the Bombay Presidency in 1883, and again ten years later. In the young "hopper" stage this locust crawled on the ground, from which it was scraped off by men into a kind of bag, and also up trees, from which it was driven by spraying; it had cost 14,000*l.* to get rid of them, but the money had been well spent. In Canada and South Africa arsenic poisoning was resorted to against locusts. A second plague, the wire worm, had recently become a serious pest in England, as it occurred in all new land when first put under the plough; ploughing the first crop of mustard or clover under seemed to afford some help. The American chinch bug, and still more the spring-grain aphis, were tiny insects destroying the whole plant (maize, *e.g.*) by their enormous numbers; they were combated with some little success by nursing their natural enemies, certain parasites and fungus, and by removing hedges round the fields which gave the insects shelter during the winter.

In the case of the weevil, to which Professor Lefroy then turned, the small beetle, about 4 mm. long, distinguished by a curved beak, does not attack a plant, but each grain of wheat separately by laying an egg into it, and yet it does immense damage in grain stores. Professor Lefroy spoke of what had been done in Australia. When the 1918 crop was coming in, over 200,000,000 bushels of wheat had accumulated and were awaiting shipment. The wheat was stored near railway stations, stacked in sacks on a flooring of old railway sleepers, and a corrugated iron roof was placed on the top of the sacks. Mice got into the stacks, some sacks were destroyed, the roof collapsed, the rain gained access, and the ground was deeply covered with loose damp grain, the proper breeding ground for the weevil (chiefly calandra oryzae, also calandra granaria or grain borer and rhi opertha).

When Professor Lefroy was sent over to Australia he found conditions very bad, especially at Enfield, near Sydney, which has a very damp climate. A special feature was that new improved stacks had been placed near old ones and had evidently been infected by them. The weevils have wings, but do not use them, preferring to crawl. On his suggestion a mixture of naphthalene and lime was spread on the ground; each layer of sacks was placed on a separate floor of sleepers, leaving ventilation space; the roof was put on special posts, and this part of the structure was the first completed before any sacks were piled up; finally the sides of the stacks were closed in with canvas. The second problem was what to do with the grain full of weevils, beetles, and eggs and larvae inside the grain. Various means had been tried; chemicals made the grain unsaleable; a fortune may yet be made in that way, however. In a static electric field of 40,000 volts between copper plates the larvae stood on their heads or tails, but they did not mind even 60,000 volts. A heat treatment process, however, answered.

In America it had been found that grain can be dried at 158 deg. F. without losing its baking power. Professor Lefroy observed that the weevils were killed by exposing the grains to 145 deg. F. for 3 minutes—which is surprising. But when he heated the grains by steam coils in boxes provided with an opening at the bottom, the grain would not flow out. They therefore made boxes with two perforated double bottoms; the grain passing through a hole in the upper bottom formed a cone on the lower, but an oscillating grid between the two bottoms maintained a steady discharge. Machinery separated the grain from the weevils, which have not been utilised so far; it is possible they might be used for soap-making. The eggs, we are afraid, remain in the grain; but they will not do much harm. Both the stacking and cleansing of the grain by machines dealing with 1,000 bushels per hour has proved quite successful according to reports lately received by Professor Lefroy.

TEMPLETS, JIGS AND FIXTURES.
No. XXI.

By JOSEPH HORNER.

THE illustrations in this article are those of a remarkable series of fixtures designed for dealing with motor engine castings for automobiles and aeroplanes. They are by the Ingersoll Milling Machine Company, of Rockford, Ill., U.S.A., for service on the combined horizontal and vertical-spindle machines, which are the firm's speciality. They afford a revelation not only of fixtures that include some original methods devised for the support and fixing of the work, but also incidentally of the immense value of the horizontal type of machine, with its combinations of face and edge-milling cutters when different faces have to be tooled without resettings, and when mass production is desired. Only one machine can enter the lists against these, and the claim is made and is doubtless justified that the milling machines of these designs turn out work 50 per cent. cheaper than planing, the cost including the entire cost of expensive cutters, grinding, repairs, and all charges.

The drawings, Figs. 599 to 601, and the photograph, Fig. 602, illustrate a massive fixture, the leading characteristic of which is the adoption of methods specially adapted to hold a very large and very light casting to be milled on an Ingersoll machine. It is of aluminium—the lower portion of the crank-case of an aeroplane motor. It is easily distinguishable in the photograph by its light tint, and is seen in dotted outlines in the drawings of the fixture. Obviously, unless careful precautions were observed, the setting and clamping of

TEMPLETS, JIGS AND FIXTURES.

Fig.599.

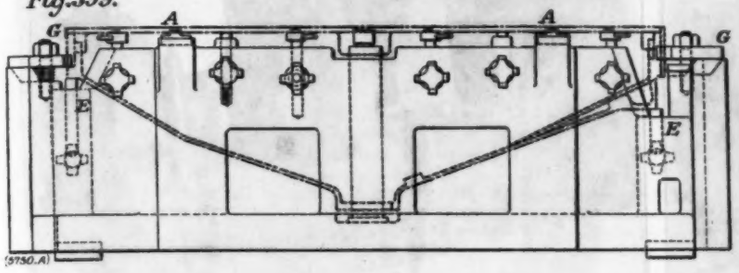


Fig.600.

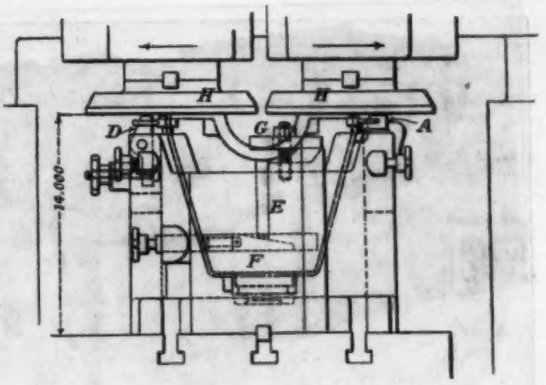
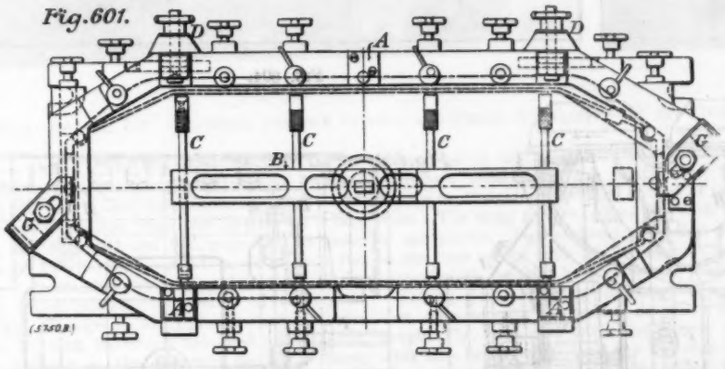


Fig.601.



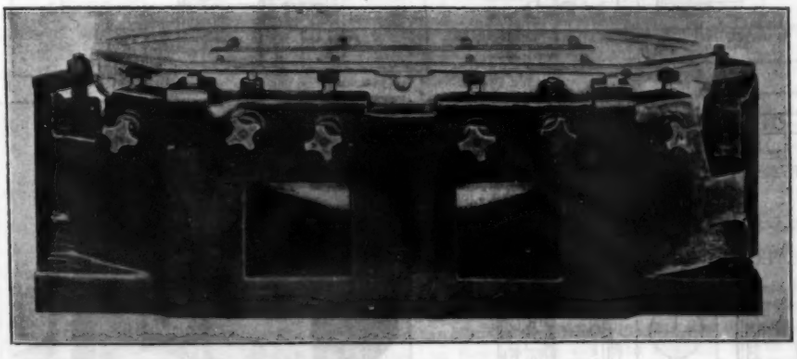


FIG. 602.

FIGS. 599 TO 602. FIXTURE TO HOLD LARGE AND LIGHT CASTINGS ON AN INGERSOLL MILLING MACHINE.

so flimsy an article would result in its serious distortion. Yet it must be held securely, in order to enable it to resist the pressure of the two face milling cutters employed (see Fig. 600).

The fixture body is very solidly made, with metal of substantial thickness, and deep enough to nearly enclose the crank-case. It fits to the machine table with tongues, and is bolted down through three lugs. In the photograph the lower part of the crank-case is seen through the lightening holes cast in the sides of the fixture. The flange stands only sufficiently high above the top of the fixture to leave room for the plungers by which it is supported. These are a constant feature in these and other Ingersoll fixtures, and are rather closely spaced in order that the thin flange shall be supported against the pressure of the heavy cut without risk of its deflection. There are two classes of these plungers shown in the illustrations. Those of one set are simple plugs adjusted vertically under the flange, supported on springs, and clamped each with its set screw having a head or knob of star shape. Alternating with these are other plungers of eccentric design, each eccentric being turned with a little hand lever. These fulfil a double function. The edge of the plug or plunger makes contact with the edge of the flange to afford it lateral support, while the eccentric disc is turned sufficiently to sustain the flange underneath. Both these sets are seen clearly in the drawings and photograph. The height of the flange is set by means of three height-locating blocks A, which determine the vertical position of the casting in the fixture, to which the plungers have to be adjusted. These height blocks are carried in seatings on the fixture body, and include two sets differing in height, having $\frac{1}{16}$ in. of difference, one set being used during the roughing cut, the other while the finishing cut is being taken. These fittings concern the exterior flanged portion of the crank-case. But some additional precautions are necessary to prevent risk of lateral pressure of the casting occurring inwards, which might easily result from the pressure of the face cutters. To provide against this, a spreader bar B, Fig. 601, seen also in the photograph, Fig. 602, is fitted longitudinally, being supported on a central stake. Four rods C pass transversely through the spreader, each carrying a shoe at opposite ends, one shoe on each being tightened with a knurled nut on the bar, so adjusting the pressure against the inside of the crank-case. Two hinged clamps D are set in opposition to the adjustable shoes in the end rods, gripping against the edge of the flange.

A casting that is prevented from chance of possible movement in so many directions does not need much clamping, and the scheme of the fixture is intended to avoid it. The casting is not strictly fastened down anywhere in the usual sense, since that would be provocative of spring. There are two hold-down clamps only, and these bear on portions of the ends of the casting just beneath the flange in direct opposition to end plungers. The grip is that of a vice which has no tendency to distort the casting by flexure. And at the two ends, two plungers E are set to take a bearing under the casting there. To adjust the height of these, a wedge is employed F, Fig. 600, moved along with a screw from outside, which raises or lowers E. The two spring clamp-plates G hold in opposition to the plungers E, gripping on a ledge or bit of flange shown in each of the views. The clamp screw is tapped into the fixture, and the clamp takes a level bearing on an abutment piece. It is slotted for its bolt, to be slid along into and out of contact with the section which it grips. There can be no deflection and spring with this arrangement. The two face milling cutters are shown at H, H, Fig. 600, attached to vertical spindles on the cross rail of the machine. They have inserted teeth, clamped in the discs.

Some succeeding illustrations show fixtures for the milling of portions of cylinder castings of those shapes in which the upper portion of the crank-case is cast in one piece with the cylinders. In the first example, Figs. 603 to 607, page 300, four castings are held in one fixture, and are being milled with six face cutters simultaneously. Two castings are held in the upper part of the fixture, and one cylinder head on each end. The photograph, Fig. 603, shows these castings *in situ*, the other, Fig. 604, the fixture alone unloaded, to show the various supports and fastenings. In the drawings, Figs. 605 to 607, the castings are outlined in their places, and the six facing cutters are shown in Fig. 605.

The scheme of support for the cylinder castings is that of rows of spring-backed plungers, with their upper ends bevelled, set in the body of the fixture at an angle of a few degrees from the vertical, and having their bevelled ends abutting on the under sides of the flanges. Each is clamped after setting with a hexagon-head set screw. These are seen in both photographs, and in detail in the drawing, Fig. 605. To prevent slip of the plungers from occurring, each set screw takes its bearing on a bevelled recess—a kind of key groove which prevents the plunger from displacement under the pressure of the cut. This valuable little detail will be observed also in subsequent drawings.

Lateral pressure is exercised on the castings, pressing them against abutment studs, with one central bolt A, which is caused to push two horizontal plungers B to right and left through the medium of a conical collar seen in Fig. 605, which, when pulled upwards produces pressure on the bevelled ends of the plungers, thrusting and holding the castings to right and left. The pressure is elastic

TEMPLETS, JIGS AND FIXTURES.

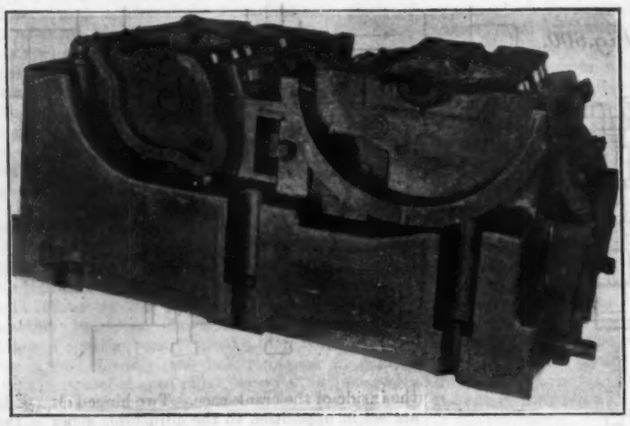


FIG. 603.

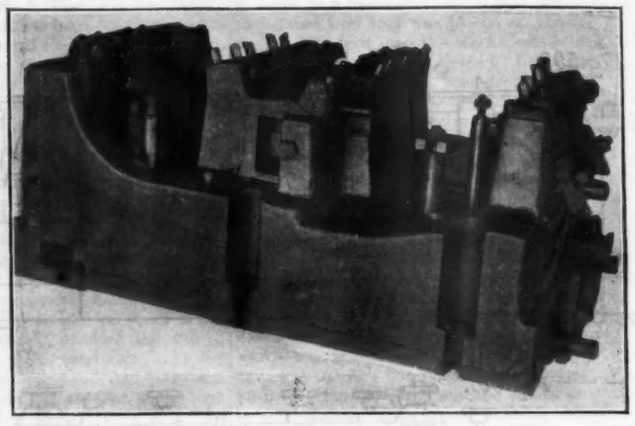
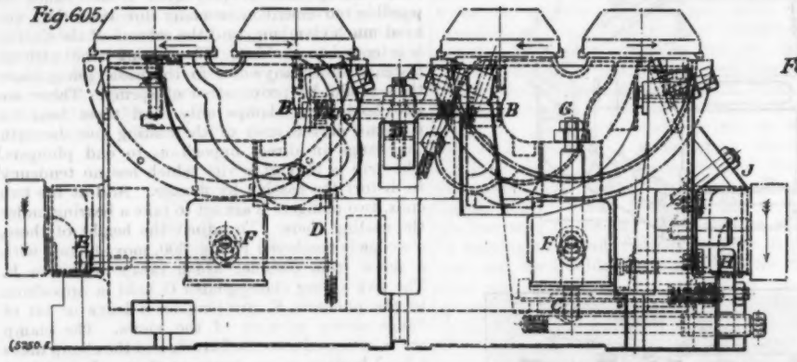
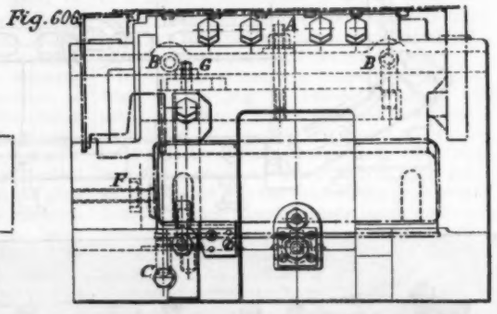
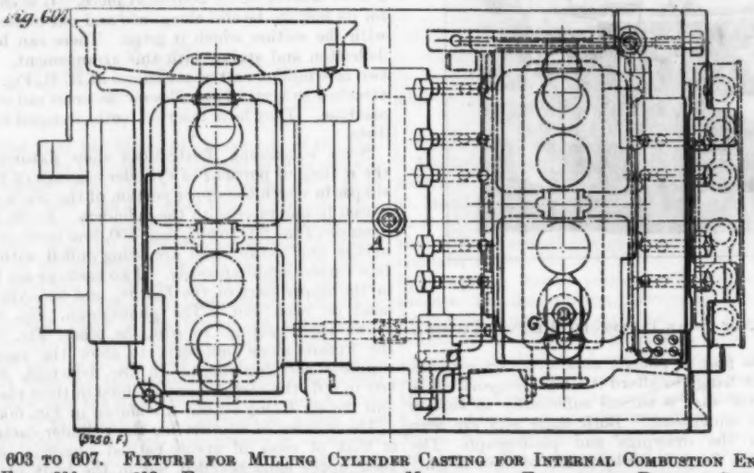
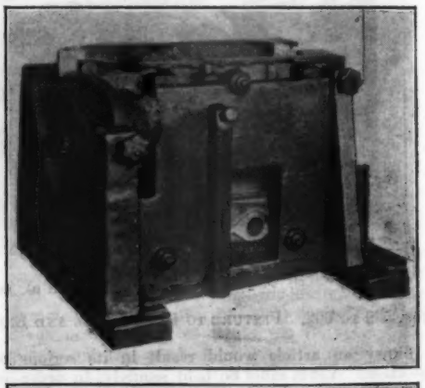


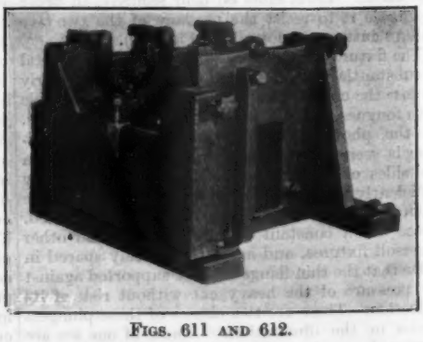
FIG. 604.











FIGS. 611 AND 612.

FIGS. 603 TO 607. FIXTURE FOR MILLING CYLINDER CASTING FOR INTERNAL COMBUSTION ENGINES. FIGS. 611 AND 612. FIXTURES TO BE USED IN MILLING THE FLANGE AND BEARING SLOTS IN CYLINDER CASTINGS FOR INTERNAL COMBUSTION ENGINES.

and accommodating, being cushioned with springs encircling the rods B. One of the rods is seen projecting in the photograph, Fig. 604, to the right of the central portion of the fixture, and the central bolt is also visible. Another setting or abutment screw is used to support the mouths of the cylinders which are also located laterally, as shown at C, in Fig. 605, the cylinder resting on a stud with its bolt against a shouldered piece. After being set the stud is locked with a plunger having a bevelled slot to receive a conical point on the tail of the stud. The plunger is pushed along with a set screw from the end of the fixture against the pressure of a spring. This screw is seen also at the right hand end of the photographs, Figs. 603 and 604. Underneath one section of the casting that stands some distance away from the cylinder support, another spring plunger is fitted to steady this portion. It is shown at D, in Figs. 603 and 605, secured with a long screwed rod pushed inwards with a set screw E from the outside. The plunger has the usual bevelled recess to prevent slip. Locating pins are also set at F, F. Each casting is clamped with two bolts situated about the axis of each, and near each end. These are seen in the drawings, and in the photograph, Fig. 604. They pass through the bores of the outer cylinders on the upper ends of which the clamp plates take their bearings (compare Figs. 605 and 607). The clamps have slot holes for the bolts.

The cylinder heads that are attached to the ends of the fixture to be tooled simultaneously are seen in the photograph, Fig. 603, and in the drawings, Figs. 605 and 607. These are fixed with clamps H below, entering passages, which pull the castings up against the ends of the fixture, and with diagonal clamp plates J above that bear on the outside and push the castings downwards to their locating

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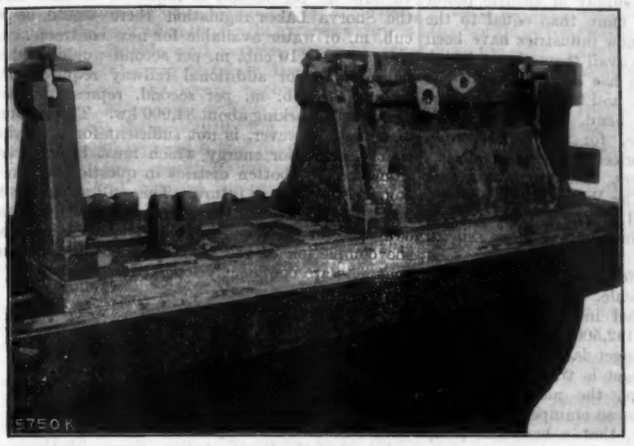


FIG. 616.

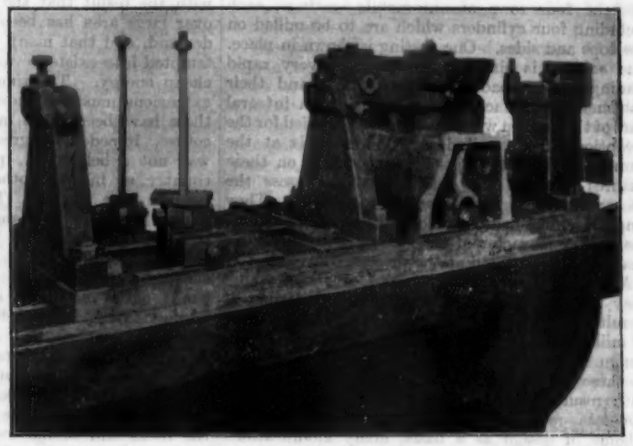


FIG. 617.

FIGS. 616 AND 617. FIXTURES FOR THE SECOND AND THIRD OPERATIONS ON THE CYLINDER CASTING OF AN INTERNAL COMBUSTION ENGINE.

abutment blocks. The facing pieces and locating plates are seen screwed to the fixture end in Figs. 605 and 606, and in the photograph, Fig. 604.

The next examples, Figs. 608 to 610, on Plate XVIII, and Figs. 611 and 612, page 300, are those of fixtures for the first operation of milling the bottom or flange, and the bearing slots of a cylinder casting, which includes its portion of the crank-case. The photograph, Fig. 611, shows the cylinder in place, Fig. 612, the fixture unloaded. The casting is seen outlined in the drawings *in situ*. Some subsequent illustrations show second and third operations on the same casting. Four cylinders are cast in one with the upper part of the crank-case, and the metal is light throughout.

It will help to an understanding of the views mentioned to note that the portion of the fixture which is seen in the foreground in the photographs, Figs. 611 and 612, corresponds with that at the left hand in Fig. 608, and with that in the upper portion of Fig. 609. Hold-down bolts go through the slotted lugs there on the extended feet, and others in holes within the fixture body. The casting is almost wholly enclosed in the fixture, little more than the flange appearing above its top face. One fixture holds a single casting during the performance of one operation only, that of milling the flange joint. As previously, the casting is supported on plungers abutting on the underside of one flange, supplemented by supports at other convenient parts, and actual clamping which might cause distortion is reduced to the minimum. The plungers—three in number—are spring-supported, and again their set screws pinch on inclined surfaces to prevent risk of slip. The support of the casting is taken under the flange partly on these diagonal spring plungers along one flange, and partly on two height blocks under the opposite flange. The casting is secured laterally from opposite sides with several set screws, shown. These elements take charge of the upper portion of the piece of work. Various other plungers support and steady the lower or cylinder portions, bearing on lower faces, and on opposite sides. Some are of the wedge-adjusting type. One, A, is noticeable for its great length, Figs. 608 and 610, turned with a knurled head outside the fixture, and extending to the farther side of the casting. Three clamp plates hold the cylinder down, two at one end, one at the end opposite. Two, B, B, at opposite ends, are alike, the third C, holds in opposition to a long plunger that is set up with the knurled head D on the end of a long adjusting rod. The plunger and clamp grip without producing flexure. The height of the cutter is set by a gauge seen at the right-hand end of Fig. 609.

The drawings and photographs, Figs. 613 to 615, on Plate XVIII, and Figs. 616 and 617, above, show a fixture for performing the second and third operations on the cylinder. The second operation comprises milling the top flange, and the small flanges on the sides, the third is that of milling the ends. The same fixture is used for both these sets of operations. Two castings are being dealt with at one time on the table of the machine, each being carried on its separate base plate.

Taking, first, the rig-up for the second operation, this is shown with one casting *in situ* in the photograph, Fig. 616, and with one fixture unloaded. This also corresponds with the drawing, Fig. 613. The cylinder flange previously milled now rests on facings screwed to the baseplates of the fixture, to which it is clamped down with two short eyebolts that pass into holes in opposite ends of the cylinder casting, as shown in the photograph, Fig. 616, and in the drawings, Figs. 613 to 615, using ordinary spring clamps. The clamp plates A are double-ended, and are pivoted on a bolt to be thrown aside when the cylinder is turned to right angles for the third tooling operation. The cutters used are shown in place in Fig. 613, one milling the top, and two, the opposite sides. The positions of their faces are set with gauge plates. The plate B, Fig. 615, is used to set the cutters that face the small gland-shaped flanges on the sides.

During the third operation, the castings are set across the fixture as in the photograph, Fig. 617, and in the drawings, Figs. 614 and 615. It is laid on facings, and set with locating blocks by the edges at one end, and one side, and clamped down with the two long eyebolts C, going through the bores of the two end cylinders, and also with a spring clamp D, low down on one end, all being seen also in the photograph, Fig. 617. The uprights play no part in this fixing. The setting of the milling cutters is done with an end plate E, Fig. 615.

Figs. 618 to 620, on Plate XVIII, and Figs. 621 and 622, on page 312, show two distinct fixtures designed for holding different pieces of work mounted on one machine table and going through the machine at the same time. This is an example of a combination which is often desirable in plants where the production is not sufficient to warrant the outlay on machines to deal with each piece or each operation separately. In one fixture, a flywheel housing is mounted for the performance of first and second operations, in the other a cylinder head for the first operation. Three cutters are in action simultaneously, two working on the housing and one on the head. Fig. 621 shows the pieces mounted, Fig. 622 the fixtures unloaded.

The housing casting is one that is much less liable to suffer distortion in the setting up and clamping than the very slightly-designed forms already shown are. It is outlined in place in Figs. 618 to 620, and is seen in the photograph, Fig. 621. It is supported on facings on the fixture base, and on two spring plungers A, each with its set screw. It is gripped laterally, Figs. 618 to 620, between two screws B, set diagonally in deep lugs cast on the fixture, and two vertical clamp plates C with buttons set in opposition to these. The plates C grip extensions on the housing against surface blocks upstanding on the fixture. A bracket on one side, Fig. 618, carries a vee block in an eyebolt as a locating element. Since this fixture provides for two settings, and two operations, two sets of combination clamp plates are required to hold the casting down near the ends, and a combination set about the centre. These are not all shown in the photograph, but they are on the drawings, and in the unloaded photograph, Fig. 622. The plates D, E, about the centre, grip the casting near opposite edges, the casting having been turned over between operations, and those F, G, clamp on lugs on the housing, one being shown holding on a lug in the photograph, Fig. 621.

The fixture for the cylinder head, Figs. 618 and 619, and 621 and 622, receives the casting against a vertical face. A fixed button below, and two horizontal spring plungers above, make contact with bosses on the casting. It is carried on spring plungers below, Fig. 618, with serrations, and is clamped down on them with two plates having serrated faces. Springs throw the plates off on release of the nuts.

In the foregoing illustrations we light upon certain simple elements frequently repeated. As we have noted in some previous articles, every firm evolves and standardises elements which are in more or less degree peculiar to its own practice. Here they occur mostly in the form of simple spring plungers, provided with an efficient lock in the shape of a set screw bearing on a sloping seating. The spring support enables the plungers to accommodate themselves to inequalities on the surfaces of the castings, so relieving them of strains during setting. Another feature that appears on the original shop drawings from which these illustrations have been made is, that every individual item, however minute and apparently trivial is a standardised form, each labelled with its own distinctive number to be taken from stock by its number for use on numerous fixtures of all kinds. The organisation of such a system favours economy of time in the shop.

The preceding illustrations have been those of articles held singly or in duplicate. Two succeeding photographs are examples of mass production. Fig. 623, on page 312, shows fixtures for transmission cases held in a double row. One case is seen loaded in the foreground. The castings are finished on the top and on the side at the same time, four cutters being in operation on the machine. Each fixture carries two castings, but a row of them occupies the machine table. Fig. 624, on the same page, is an even more striking illustration

of the manner in which quantities of fairly large castings are dealt with on one table of maximum dimensions. The long fixture shown is designed to take four rows of automobile castings, each including four cylinders which are to be milled on the tops and sides. One casting is shown in place. The scheme is simple, providing for very rapid loading and unloading. Clamp plates and their abutment or surface blocks are made an integral part of the base on which facings are provided for the reception of the cylinders. One marvels at the immense output that justifies the outlay on these fixtures, and on the machines that possess the necessary facing heads, and large tables. They emphasise, like many previous examples have done, the severe character of the competitive conditions that have to be faced at the present time.

Many of these operations, and others of which they are representative, would not be possible of simultaneous accomplishment in any other way than in milling machines of the slabbing or plano-miller design. The Ingersoll Company have specialised in these to the exclusion of other machine tools, with results that are generally familiar, but not the less remarkable. While adopting a broad scheme of design as a basis, many modifications are made—standardised in various forms—while lengths of tables and some other details are constructed to the requirements of individual firms. So that, derived from the fundamental design, machines and batteries of machines are built for shops in which classes of work are done of totally unlike characters. Largely associated with, and contributing to the efficiencies of the machines is the equipment of cutters, varied in designs, and in dimensions, to deal with vertical and horizontal faces differing widely in their widths.

The machines are of protean forms. They all have the horizontal spindle. One, two, or three vertical spindles are provided. In some, two vertical spindles are carried on saddles on the hinder face of the cross rail, away from the horizontal spindle in front. Some machines are fitted with a spindle that can be set at any angle, and can also be thrown up out of the way when not in use. Side-cutting over large faces is done from horizontal spindles, having their heads fitted on the housings, with vertical adjustments. In many machines one housing is made removable to permit of the carrying of work on the table which is too wide to pass between the housings. Or work of this kind is sometimes put on a circular table carried on the reciprocating table in front of the housings. Machines fitted with portions of, or with all these equipments, possess enlarged capacities for dealing either with work that is attached directly to the tables or to intermediate fixtures. Both methods are adopted extensively. One valuable provision is peculiar to some of these, that of cross-feed to the vertical spindle heads carried on the cross rail. This is particularly useful when ends, or transverse faces have to be milled, which can then be done without re-fixing the work at right angles. The milling cutters used are various, are of numerous edge and face designs, and a large place is occupied in some classes of work with the built-up gang mills. A very large proportion—nearly all the larger sizes—have inserted cutters of high-speed steels, fastened in various ways, and set with front rake, constituting them true cutting tools. To illustrate these would take us rather away from the subject of fixtures. But they contribute largely to the efficiencies of the machines.

THE EXTENSION OF HYDRO-ELECTRIC POWER IN SWEDEN.

FOR some years past we have kept our readers fully informed as to the great works which have been laid down in Sweden* for rendering available the vast amount of water power which that country possesses. The Government has wide and extensive authority for dealing with the rivers and catchment areas, and long ago appointed the Royal Swedish Waterfalls Board with powers not only to investigate and report, but also to execute works. This board has done its work zealously, with the result that the supply of electric power over large area has been more than equal to the demand, and that many new industries have been tempted into existence to avail themselves of such cheap energy. The time has come when further extensions must be made, and to a certain extent these have been taken in hand. The war has, of course, impeded progress, for although Sweden was not a belligerent, prices have risen in that country as in most others. The time, however, has not been wasted. The Waterfalls Board has pursued its surveys and plans, and has carried out minor works for impounding the rainfall and the melting snows. It is ready as soon as funds are available, for carrying out further works on a very large scale. A very important power station is projected in Lapland, with a calculated capacity of 192,500 kw. This time it is the historic Horsprauget falls that are to be exploited. The Horsprauget is the Saltus Leporinus of ancient explorers, the name indicating that the fall in one place is so cramped in between the rocks and so narrow, that a hare can jump from one side to the other. Like the Porjus falls it is on the Lule river, some 7 kilometres lower down the stream than the latter fall. The Lule river debouches into the Gulf of Bothnia about 50 miles from the Russian boundary which lies at the apex of the gulf. The river is the outlet of a chain of lakes, of which the lowest is Stora Lulea. The river runs south-east, and is about 100 miles long, while the lakes are about 75 miles long, and are entirely within the Arctic Circle. The lakes are fed by many rivers, some of which rise almost on the coast of Norway, which here is a narrow strip of country about 25 miles wide.

The plant and water supply in connection with the Porjus power station have been already largely utilised, and the development has been quicker than expected. Besides energy to the Kiruna-Riksgransen railway, and to the iron ore deposits, current is being, or will very shortly be, supplied to a metallurgical smelting works, to a large iron-reduction furnace, to a soda factory and a tar factory. In addition energy will be wanted for the further electrification of the Lapland line, eastward from Kiruna to its other terminus at Luba on the Bothnian gulf. The load of the* Porjus section, as far as three-phase current is concerned, amounts to about 15,000 kw., and after the extension now in hand the call for industrial purposes, according to agreements already entered upon, will amount to double that aggregate or 30,000 kw. This represents the full capacity of the Porjus station as regards three-phase current after the completion of the present enlargement.

So as not to impede the industrial development now going on in that part of the country, additional generation of electric energy has become a necessity, and two alternatives have been considered with this end in view. The Porjus station might be further extended or a new power station built at another of the State falls in the Lule River. The former alternative was discarded because the local conditions would necessitate work of a costly and somewhat difficult nature, and in addition the lake system of the Lule River would have to be further regulated beyond the scheme adopted in 1913.

As regards further regulation of the Lule River and lake system, investigations undertaken by the Waterfalls Board have shown that it will be most advantageous to regulate the system of lakes lying at about the same level and through which one of the tributaries of the Lule River, the Kärtje River, passes. These lakes are called the Suorva Lakes, and are situated above Kärtjejaure, at the mouth of which the Kärtje River forms the large and famous fall, Stora Sjöfallet. After the proposed regulation the falls at Porjus and lower down the river will have a constant volume of water of 160 cub. m. per second, whilst the 1913 regulation only would lead to 50 cub. m. to 60 cub. m. per second. If all the energy which the Waterfalls Board at present has contracted to deliver from Porjus has to be made available as primary energy, that is available throughout the year, a volume of water of some 75 cub. m. per second is required, so that after the Suorva Lakes regulation there would be 85 cub. m. of water available for new contracts. Of this, at least 10 cub. m. per second would need to be reserved for additional railway requirements, leaving 75 cub. m. per second, representing for continuous working about 34,000 kw. This amount of energy, however, is not sufficient for satisfying that demand for energy which must be expected from the Noorbotten district in question within a comparatively near future. This will appear from the fact, that beyond the energy which will become available for delivery from the Porjus station after the completion of the second stage, the following contracts are confidently looked forward to.

	Kw.
Norrbotten Ironworks	35,000
Porjus Smelting Works	5,000
Stockholm Superphosphates Company, Biphosphate, &c.	10,000
Total	50,000

or 71,500 horse-power.

Such addition in primary energy cannot be obtained at the Porjus station, even with the most comprehensive regulation of the Lule River, and further plans for an extension of the Porjus station have therefore been abandoned for the time being.

The Horsprauget Falls, as already mentioned, are located in the Lule River about 7 kilometres below Lilla Porjusselet, the lowest of the Porjus falls. Over this distance the river has a fall of about 29 m., divided between several falls, the Lillselfors (6·6 m.) and the Langselfors (15·4 m.) being the most important. The head in the Horsprauget itself is about 75 m. over a distance of 4 kilometres. Below the Horsprauget proper lie the Djupselet 0·9 kilometres long, and immediately below the latter the Pakkoselet, 0·5 kilometres long. The aggregate fall from Porjusselet to Pakkoselet is about 107 m. The volume of water at Horsprauget is slightly larger than at Porjus.

It is proposed to exploit the above falls in one installation which can be done by constructing a high dam at Horsprauget to about the same level as the water at Lilla Porjusselet. This dam will be materially larger than any of the dams hitherto constructed in Sweden. It will be about one kilometre long and about 40 m. above the ground at its highest point. The construction of this dam is calculated to occupy some five years. By lowering the water level, when required, two metres below the dammed height, a storage of about 5,000,000 cubic m. will be obtained, which is sufficient for equalising load variations during the 24 hours. Regulation for longer periods can be secured by joint working of the Porjus and the Horsprauget power stations through the storage in Stora Porjusselet and Stora Lule Vattult. The dam will consist of a central portion of masonry, with the ends adjoining the shores, of rubble or earth. As at the Porjus dam due provision has been made for dealing with the pressures of ice which with the severe climate of Lapland may prove unusually great.

In this connection two kinds of ice pressures have to be provided for, namely, that arising from broken ice colliding against the dam, and the pressure which is caused by the ice cover of the lake above the dam expanding under the effect of the sun. The former, which is at its greatest during storms at the ice-breaking season, and which will be about the same in northern and more southern climates, is of comparatively smaller importance, inasmuch as experience has shown that a properly constructed dam always will be able to resist such pressure. The pressure arising from the expansion of the ice from warmth is not only greater with large dammed-up lakes than with smaller, but also is increased in northern latitudes owing to the greater thickness and stronger consistence of the ice. The maximum pressure to be resisted is that which will crush the field of ice in the reservoir, and cause it to rise in hummocks. The strength of the ice depends upon the temperature, and is stated to vary from

* See ENGINEERING, vol. lxxxv, pages 58, 235; vol. lxxxvi, page 816; vol. lxxxvii, page 829; vol. lxxxviii, page 509; vol. xci, pages 778, 811, 816; vol. xcii, page 374; vol. xciii, page 21; vol. cii, page 562, pages 29, 51, 171, 563. "State Water-Power in Sweden," vol. clv, page 524.

* See ENGINEERING, vol. c, pages 385, 411, 435.

120 to 600 tons per square metre according to the temperature and the density. However, the ice field does not fail by direct compression, but by bending. These considerations caused the dam at Porjus to be constructed in loose material, but this system is not satisfactory when the height exceeds a certain maximum. Rubble and earthen dams of considerable height have certainly been adopted in other countries, the record probably being the earthen dam, 35 m. high, at Belle Fourche, Dakota, U.S.A., built in the year 1910. But the Horsprauget dam will in places exceed this height, in addition to which the local conditions are not very suitable for this kind of dam. A composite structure has been designed, with special features to resist the pressure of the ice. At the right shore it is proposed to use the same type of deposited dam as at Porjus, where the height does not exceed 15 to 20 m. The central portion is to be of masonry, with a layer of earth on the water side of the dam, partly carried on an offset or shelf, the earth to be 4 m. in breadth at the top with a side slope 1 to 1·5. The effect of this layer of earth is, in the first place, that the ice, under expansion, slides up the upstream sloping side of the dam, and secondly, should the ice not slide up on account of its being frozen fast to the dam, the elastic earth layer, the interior of which cannot freeze on account of its dimensions, will be deformed and the ice pressure thereby become reduced. Even with such an elastic earthen layer on the crown of the masonry dam, the expansion of the ice will affect the masonry and the resulting pressure must be provided for.

In the power station at Horsprauget, the turbine intake is to be placed immediately against the dam, thereby an inlet-tunnel (or canal) is avoided, but the outflow tunnel will be correspondingly longer. It will be 2.8 kilometres long and terminate at Djupselet.

The net height of fall is calculated at about 101 m. before regulation of the falls between Djupselet and Pakkoselet. The capacity with a regulated volume of water of 160 cub. m. per second amounts to 134,000 kw. It may, however, as at Porjus, be deemed advisable to lay out the installation, when completed, for a larger capacity, 11 units, including reserve, of 17,500 kw. each, making an aggregate capacity of 192,500 kw. The first stage comprises five units and one reserve unit, representing a capacity of 87,500 kw. and a water consumption of 105 cubic m. per second.

The regulation work in connection with the Horsprauget power station, as at a number of similar undertakings, is a very important question. The great Lule river proper may be said to commence at its outflow from Great Lulejaure, where the Luleluspe fall, partly dammed by the Porjus station, is located. The more important tributories to Great Lulejaure are the Sjaunja River and the Langas at Jaurekaska. The largest tributaries of the Langos, again, are on the Vietusjokk, which has its sources near the Norwegian frontier, passing on its way through the lakes Sitasjaure, Autajaure, Teusajaura, Petsats and Satisjaure, and the Kartze River. Immediately above lake Kärtjejaure, and about at the same level, lie the lakes Suorvajaure, Vuoksajaure, Alemusjaure, and Luoktaujarkajaure, with Kaskajaure and Svaltjajaure, which lakes in this connection are called the Suorva Lakes. Into these lakes, at their upper portion, flow two somewhat important tributaries, the Ratja River, coming from the north-west and passing through the lakes, the Ketsak, the Seggokjaure, the Abmatsjaure and the Ratjajaure, and the Vuoja River, coming from the south west, and passing the lakes Virijaure, Vasterijaure and Katjasaure.

The areas of these lakes are as under:—

	Sq. Kiloms.
Great Lulejaure...	166
Virijaure	109
The Suorva Lakes	98
Vastenjaure	84
Sitasjaure	66
Langas	54
Satisjaure	50
Ratjajaure	20

The aggregate surface of all the lakes within the catchment area above Lulejaure amounts to about 890 square kilometres, and the total catchment area of the river at the same point is about 9,860 square kilometres, so that the lake area amounts to about 9.3 per cent. of the total catchment area.

The purpose of the regulation is to create as great a low-level volume of water as possible for the Porjus power station and further stations lower down the river. In order to effect a complete regulation of this nature it would be necessary to construct regulating dams not only at Great Lulejaure, the one nearest Porjus, but also at other lakes, of which several are situated above the tree and shrub border, in desolate and inaccessible mountain districts.

Complete calculations and investigations have been made at the instance of the Royal Waterfalls Board of the following lakes:—

(*a*) Great Lulejaure.
(*b*) Satisjaure.
(*c*) Langas.
(*d*) The Suorva Lakes; and
(*e*) Virijaure.

(*a*) Several regulating schemes have been considered at the end of Great Lulejaure at Luleluspen, but the more comprehensive plans, comprising a high dam and various installations, would entail a heavy expenditure and might not prove very reliable, inasmuch as the ground is unstable. It has therefore been decided to use Great Lulejaure as an equalising basin by means of which irregularities in the tapping of the storage lakes higher up can be equalised. This can be done all the more easily since the upper water level at the Porjus regulating dam is about at the same level as the low water level in Great Lulejaure. By dredging the bottom of Luleluspen, the low water level in Lulejaure can be lowered below the above-mentioned level, at which it will not be necessary to tap a larger volume of water from Lulejaure than that which corresponds with the average requirements per week at Porjus power station. As the demand for water for power generation varies and decreases during the night, as well as during Sundays and holidays, a corresponding volume of water can be contained in Great Lulejaure as well as in Great Porjusselet between the dam at Porjus and Luleluspen. The dredging of Luleluspen, which has already been undertaken to a great extent, will only be required for a moderate yearly regulation of the waters in question. For this purpose a dam of limited dimensions and with sluices capable of being closed has been constructed, whereby the low water volume can be raised from the previous 24 cub. m. to 50 cub. m. to 60 cub. m. per second.

(*b*) The regulation of Satisjaure will be effected by a deposited dam at the end of the lake to a height of 12 m. above the present high water level, but this work may be postponed to a later and more complete regulation of other lakes.

(*c*) The construction of a regulating dam at the end of the Langas Lake would prove relatively expensive on account of the low lying country in this locality, and the regulation of the lake can be brought about in more advantageous manner both technically and financially through regulation of other lakes.

(*d*) The regulation of the Suorva Lakes having been shown to be more efficient than that of other lakes we append a few additional particulars about this undertaking. The aggregate area of the different lakes coming under this heading amounts to about 98 sq. km. with the present average level, which area, owing to the nature of the shores will be materially extended by damming operations. Further, a dam of 1·7 m., or more height above the present highest known water level, will add to the above lake system the Ratjajaure, with an area of about 20 sq. km. With a height of dam of respectively 5 m., 10 m. or 13 m. above the same water level the aggregate lake area will be increased to 195,225 and 230 sq. km.; the length of the lakes in question including the Ratjajaure is more than 55 km.

Hydrographic observations as to the inflow of water into the Suorva lakes have been carried on during the years 1911 to 1917, through which period the year from September 1, 1915, to September 1, 1916, was the most unfavourable; but as the observations extend over only a comparatively short space of years, even more unfavourable conditions may prevail on future occasions. To be on the right side an even more unfavourable year than the above has been formulated by taking the poorest months during the whole of the above period and making them form a year which has been denominated X.

The greatest possible output of water at Luleluspen with complete regulation of the river and lakes in question, that is the entire inflow evenly divided during the whole period of regulation, will appear from the subjoined table. The period of regulation being taken both as one gear and two years, in the first instance the dry year September 1, 1915—September 14, 1916, and the X gear, and in the second instance the years September 1, 1915—September 1, 1917, and the two first mentioned together. These figures represent the highest possible withdrawal according to the supply of water, which cannot be exceeded during the dry periods referred to, even if all the lakes above Luleluspen were regulated. If the regulation be limited, to begin with, to the Suorva lakes and the now almost completed regulation of the Great Lulejaure, the available quantities will be reduced as per table:—

Regulation Period.	Largest possible amount of withdrawal at Luleluspen River. Complete regulation.	Regulation of the Suorva lakes and completed regulation of Great Lulejaure now going on.
One year regulation period—		
Dry year, September 1, 1915, to September 1, 1916.	161	158
X year	133	133
Two years regulation period—		
1915 to 1917	182	164
X year and September 1, 1915, to September 1, 1916.	146·5	145

The quantities are cubic m. per second.

For the sake of comparison it may be noted that the low water supply, after the regulation of Great Lulejaure now approaching completion, during the dry years September 1, 1915—September 1, 1916, and the X years amounts to respectively 57.5 and 52.5 cubic m. per second.

It will appear from the above table that the more limited regulation of the second column leaves the same result as the complete regulation, as long as the regulation period is confined to one year. If on the other hand the regulation is extended so as to comprise two years or more, the complete lake regulation leaves a better result. Regulation for more than two years, that is storing the water from a year rich in water to poorer years, is not by any means out of the question, but the observations are not yet sufficiently exhaustive to form a basis for calculations in that direction, and as the cost of the gained cubic m. per second increases somewhat rapidly with increased periods of regulation, the matter has been left out of consideration for the present.

Several alternatives have been considered in connection with the regulation of the Suorva lakes, the damming height* varying from 100.0 m. to 114.0 m., and the cost from 500,000 kr. to 5,830,000 kr., the possible withdrawals for the two years, X year, and September 1, 1915—September 1, 1916, vary from 70 cubic m. to 145 cubic m., and for the two years 1915–16–17 from 70 to 164 cubic m. per second. The third alternative, however, yields approximately the same results as alternative 4, the storage capacity not being fully exploited in the latter case. In consequence alternative 3 has been given the preference.

Both the outlets emanating from Suorvajaure will have to be provided with dams.

(*e*) Virijaure is a typical mountain lake, situated near the Norwegian frontier; it is entirely above the forest border, surrounded by stern, bare rocks. Access to it is difficult, and work on it would be very costly.

The aggregate cost of No. 3 regulation has, according to 1913 prices, been calculated at

* The damming heights refer to an optionally chosen plane, according to which the present exceptional low water level of Suorvajaure is at 96·52 m. and the highest observed water level at 100·70 m.

3,570,000 kr., whilst the cost with present prices will be about 7,000,000 kr.

The calculated cost of the first phase of the Horsprauget station, according to prices ruling at the time of building of the Porjus power station, comes out as under:—

	Kr.	Kr.
Construction of dam		12,000,000
Other water construction		9,000,000
		21,000,000
Houses, temporary or permanent...	750,000	
Railway connection, &c.	500,000	
		1,250,000
Management and unforeseen expenses, about 25 per cent. ...		5,750,000
Total for water and house construction		28,000,000
Turbines, 6 units with electric equipment for 105,000 kw. ...		4,200,000
Total		32,200,000

With the present high prices the former of these two items must now be raised to about 55,000,000 kr. and the latter to about 14,500,000 kr., or an aggregate of 69,500,000 kr. Added to this comes the Horsprauget share of regulating expenditure of 5,500,000 kr.

Of the 87,500 kw. which the first stage will make available, at least 50,000 kw. have already been bespoke; should during the first few years no more definite applications be made for power, it would not be necessary to instal more than four units to begin with instead of six.

As regards the selling price for the energy generated at Horsprauget it is proposed to charge a bare price per kw., about the same as was charged before the war at Porjus for electro-chemical and electro-thermic industries, and to add a charge representing interest and amortisation of the increased cost of construction and the interest on increased working expenses. The intending purchasers have declared themselves willing to accept these terms, as they see no chance of cheaper power being obtainable anywhere else. As regards the industries likely to profit from the new power station, the vicinity of the large iron ore deposits naturally points to electric iron smelting. The process invented by Professor Wilhelm Palmer for extracting phosphate manures from minerals containing phosphorus is also likely to require a substantial amount of energy in that part of the country, as there are almost unlimited quantities of phosphorus containing residue from the iron ore breaking and handling. Negotiations are pending with the Elektrosalpeter Co. for the supply of large quantities of energy both from Porjus and Horsprauget for the production of so-called Norway nitrates. Also the Stockholm Superphosphate Co. is negotiating for power.

There is every prospect of the Horsprauget power station yielding satisfactory financial results from the start, the more so as some of the electro-chemical industries which have sprung up at Trollhättan in all likelihood may have to move to Lapland. So far the Swedish State power stations can boast very satisfactory financial results, as will appear from the appended table, in which the first column of figures shows the proceeds in percentage, also of the estimated value of the water-power which the State already owned and thus has not had to buy, whilst this water-power is left out of consideration in the second column.

	Per cent.	Per cent.
Trollhättan	7·23	11·62
Porjus	5·03	5·21
Alfkarleby	7·67	8·76
Average	6·95	9·08

The lower percentage at Porjus is greatly owing to the power for railway traction being supplied at almost cost price, and the extension now approaching its completion will materially improve the percentage as regards the Porjus station.

STANDARD GAS.

THE autumn meeting of the Institution of Gas Engineers, a report of which appeared in our columns on October 25, 1918, has been described as epoch-making in the history of the gas industry. The chief reason assigned for this opinion arises from the circumstance that it was the occasion for the presentation of a highly important preliminary report of the Institution's Gas Investigation Committee.

The work reported upon was carried out by the Research Sub-Committee, which consists of representatives of the Institution, and of the Leeds University, under the chairmanship of Lieutenant-Colonel Arthur Smithells, C.M.G., F.R.S. (the well-known Professor of Chemistry at the University, and an eminent investigator in the domain of flame temperature), with Professor John W. Cobb, C.B.E., Livesey Professor at the University, acting as supervisor; the research chemist being Mr. James W. Wood, M.Sc.

The committee's labours originated in 1917, during the presidency of Mr. Arthur E. Broadberry, M.Inst.C.E., as the result of a suggestion by Mr. Thomas Goulden, M.Inst.C.E., chief engineer of the Gas Light and Coke Company. They were subsequently enhanced in importance by a request made by Sir George Beilby, F.R.S., chairman of the Fuel Research Board, to whom the matter was referred by the Board of Trade, that the gas industry should assist in specifying the quality and composition of gas, and the minimum pressure at which it should be supplied to the public, having regard to the desirability of economy in the use of coal, the adequate recovery of all the valuable by-products, and purposes for which gas is now used.

A preliminary period was devoted to a critical examination of methods and instruments, with a view to securing reliability throughout, and to saving time where possible. The experimental work was then transferred from Leeds University to the Nechells Laboratory of the Birmingham Corporation Gas Department, where valuable facilities had been offered, and where Dr. E. W. Smith, the chief chemist of the department, has rendered conspicuous service throughout the course of the investigation.

Having regard to what is practicable, particularly at the present time and in the near future, the tests were all made with what were regarded as good representative examples of existing appliances, and with no adjustments beyond those provided by the makers, unless otherwise ordered. The grades of gas investigated were such as are readily obtainable in ordinary gas-works practice. A survey was made of three important domestic applications of gas, namely the ring burner, the incandescent mantle, and the gas fire. In October, the committee presented a lengthy illustrated preliminary report to the Institution, and it was fully discussed.

With respect to the ring-burner tests, the conclusions set forth in the report show that the results obtained from a particular gas depend upon the number of heat units supplied, and that, provided suitable adjustments are made, the efficiency is practically independent of composition, inerts, or calorific value. It was stated that, as a matter of practical convenience, to deliver a sufficient number of British thermal units in a reasonable time, without abnormal pressure, the gas should be of moderately high calorific value, these conclusions depending presumably upon the fact that the difference between the temperature of the water (even at its boiling-point) and that of the flames of any gas mixture which has been tried, is so great that the variations in flame temperature met with in practice are negligible in effect. The addition of air to the gas at the holder did not give better results than those obtained with a properly-adjusted burner working in the ordinary way; while the pressure, &c., required to deliver the same number of heat units and perform the same heating was increased. The experiments proved that the efficiency of ring burners, properly adjusted and using the same gas, varies considerably with the type of burners employed; and that when the gas quality is sufficiently reduced, lighting back occurs with most ring burners in common use, but the limit varies considerably with the design of the burner. It varied from 500 British thermal units gross, to 400 British thermal units gross. A wide variation in grade or composition of gas can be made with reference to other uses, without impairing the efficiency of ring burners now in use.

The conclusions arrived at with reference to the experiments on incandescent low-pressure lighting showed that for satisfactory lighting with incandescent mantles it is necessary to place the mantle exactly in the zone of active combustion of the gas mixture, or, since the burner and mantle are in practice fixed, the zone of active combustion must be made to fit the mantle. This requirement is so stringent that, with all gases which could be proposed as reasonably suitable for public supply, other considerations—such as that of flame temperature—become relatively unimportant. The means of varying the position and character of the zone of active combustion were stated to be (*a*) varying the gas consumption, (*b*) varying the degree of aeration. With gases of about 450 British thermal units gross and below, the control possible to obtain by varying the consumption and aeration was not sufficient to give satisfactory illumination. With the burner used, a gas of about 550 British thermal units gross maximum to 500 British thermal units gross minimum gave the best performance, both as regards efficiency and total illumination, but gases of about 600 British thermal units gross per cubic foot gave inferior results owing to defective aeration. Gases of low calorific value and high inerts were found to be distinctly inferior on all grounds, to gases of similar low calorific value, but with low inerts, *i.e.*, consisting mainly of low-grade combustible matter. The effects of inerts up to 20 per cent. to 25 per cent. were shown to be less marked in the case of gases of calorific value, 500 British thermal units to 550 British thermal units gross, being in fact practically negligible. The maximum attainable illumination was found at about 525 British thermal units gross. When a reduction in illuminating power and efficiency accompanies a reduction in calorific value or an increase in inert constituents, the result is due immediately to the unsatisfactory size and shape of the flame and its position with respect to the mantle. A gas in which the inerts are largely in the form of air does not behave as poor gas, but as an equivalent volume of the original air-free gas.

At the time of the presentation of the report no results of experiments on inverted incandescent mantles were available for publication, but the Research Committee in its next report will have material to submit on this important aspect of the investigation.

In regard to the experiments on gas fires, the conclusions of the research went to show that with each gas fire there is a certain consumption which, for the gas used, gives the maximum radiant efficiency, and that if a fire is turned down so that less than one-half the radiants are heated, the efficiency suffers severely. It was proved that existing gas fires vary very considerably in their ability to adapt themselves to gases of different grades, and that the evidence obtained so far points to the conclusion that a difference in the grade or composition of the gas supplied, within wide limits, does not cause any considerable difference in the radiant efficiency of a gas fire, provided that the mechanical construction of the fire will allow sufficient gas to be passed, so that the same number of British thermal units per hour can be supplied to the radiant.

At the meeting great stress was laid on the fact that the report was of a preliminary character, and that therefore no recommendations as to the quality and composition of the gas universally desired could be made, although important conclusions had been arrived at even at this stage.

There is a great feeling in the gas industry that a standard gas, enacted by the legislature is a pressing need of the times. Illuminating standards are undoubtedly out of date, obviously, as the illumination resulting from the combustion of gas in the incandescent mantle is a question of calorific power, and not of candle value. A gas supply in all parts of the country maintained at a statutory standard quality and composition and at an equitable price, would be to the advantage equally of the public (the consumer), the gas undertakings who make the gas, and the manufacturers of the apparatus and appliances by means of which the gas is put to innumerable domestic, industrial and scientific purposes.

The public would benefit because they would be relieved of the necessity of making adjustments of burners, and the gas would be consumed at its maximum efficiency. Each consumer would be obtaining the greatest possible heat value for the expenditure of a given amount of money. The undertakings would be able to standardise their methods of carbonisation, and gas admixture, to produce the statutory standard gas decided upon. The manufacturer of appliances would supply gas burners, fires, furnaces, &c., on standard lines, with the knowledge that to whatever district of the country they might be forwarded they would be certain to give performances of maximum efficiency in every case.

But the most vital consideration of all—that of the conservation of the nation's coal resources—would be fully taken into account. With the introduction of a lower calorific power (standard) gas as proposed, the heat units utilised from a given weight of coal carbonised would be materially increased.

Passing on to the means of determining the heat value of the gas, it may be noted that the Gas Investigation Committee state in their report that a careful comparison of their own and other figures shows that there is a discrepancy between calculated and observed calorific values, and that this does not necessarily imply manipulative errors, either in gas analysis or in calorimetry, but is most probably due to the fact that an analysis (even when correctly carried out by orthodox methods) does not give sufficiently exact data for the accurate calculation of the calorific value. In all the results given in the report the observed or experimentally determined calorific value has been made the basis of the efficiency calculations. The committee, realising that as the effect of inert constituents upon

the behaviour of a gas is one of the principal points upon which the investigation is focussed, their accurate determination is a matter of considerable importance. Extensive trials and check results led them to the conclusion that the direct determination of nitrogen by the oxidation and subsequent absorption of all other constituents, using copper oxide under suitable conditions for the oxidation, is a process which gives both accurate and concordant results. The analyses given in the report were without exception made by that method.

Gas has, by Act of Parliament, to be measured out to the purchaser by meter, the accuracy of registration of which is certified by the recognised authorities. The consumer, therefore, may be satisfied that he is receiving the correct quantity of gas for which he pays. But there is the question of the quality of the article he receives. This is also specified by Parliament, and, as we know, has deteriorated during the war in consequence of the gas having been denuded of certain constituents demanded in the manufacture of high explosives. The purchaser of gas for whatever purpose he intends to use it—whether for lighting, heating, or power—requires to remember that he is really buying so much heat. Now, standard gas would contain a statutory number of heat units, and its value would be expressed in terms of its total heat capacity per cubic foot.

The accurate determination of this heat value is, of course, a proposition of great importance both to the vendor and to the buyer of gas. It demands an instrument the records from which shall be as trustworthy as those of the meter itself. The Gas Acts of the year 1914 directed that "total heat" value should in future be the standard of calorific value. Quoting from one of the clauses: "The apparatus for testing the calorific power of the gas shall be the most suitable for ascertaining and in making the test shall be used in such a manner, and under such conditions as to ascertain, after any necessary calculations have been made, the total heat value of the gas." The statutory method for determining the value of a standard gas must therefore be one giving its result in terms of total heat.

The "necessary calculations," however, to convert the observed "gross" calorific power to the "total heat" value, over and above those ordinarily ascertained, *i.e.*: (1) corrected volume of gas burned, (2) water collected, and (3) temperature rise, involve a knowledge of considerable data, viz., the percentage of saturation of the gas tested, the volume of air passing through the calorimeter during the combustion of each cubic foot of gas, the percentage saturation of such air, the temperature of such air, the contraction in volume of gas and air upon combustion (or the volume of products leaving the calorimeter per cubic foot of gas burned), the temperature of such products, and the percentage saturation of such products.

It is obvious that calculations involving so many factors are laborious, and open to the possibility of errors creeping in. Mr. John F. Simmance, Assoc.-M.Inst.C.E., to whom the physicist is already indebted for a number of beautifully thought-out and constructed measuring and recording devices, has invented a total-heat recording calorimeter, which in its operation itself performs all these calculations. It is made by Messrs. Alexander Wright and Co., of 1, Westminster Palace Gardens, Westminster, S.W. 1. The results are continuously recorded on a chart actuated by eight-day clockwork. What this ingenious calorimeter does is to ensure automatically that constancy or balance of volumes, temperature, and humidity, the existence of which makes the use of any formulæ or corrections quite unnecessary; and it therefore always, and under all conditions, automatically indicates the maximum heat in the gas, or its total heat value. It is impossible for the chemist or gas examiner to make any adjustments which affect this, for when the gas is lighted and the water turned on, the calorimeter itself does the correction to total heat.

It may here be stated that the term calorific value as applied to gas has come to mean the total heat value in gross heat units—the units being British thermal units per cubic foot at 60 deg. F. and 30 in. atmospheric pressure (normal temperature pressure) or, in countries where the metric system is used—calories per cubic metre at 15 deg. C. (or 0 deg. C.) and 760 mm. atmospheric pressure (N.T.P.). Mr. Simmance has designed his calorimeter to furnish automatically a record on a chart in either of these units, and (independently of the record) to enable a calorific test to be made by actual measurement of the gas burned, water heated by combustion of the gas, and the amount of heat so imparted to the water. In other words, it is a standard calorimeter with an auxiliary device recording heat units upon a chart.

It will be noticed that the record is not obtained

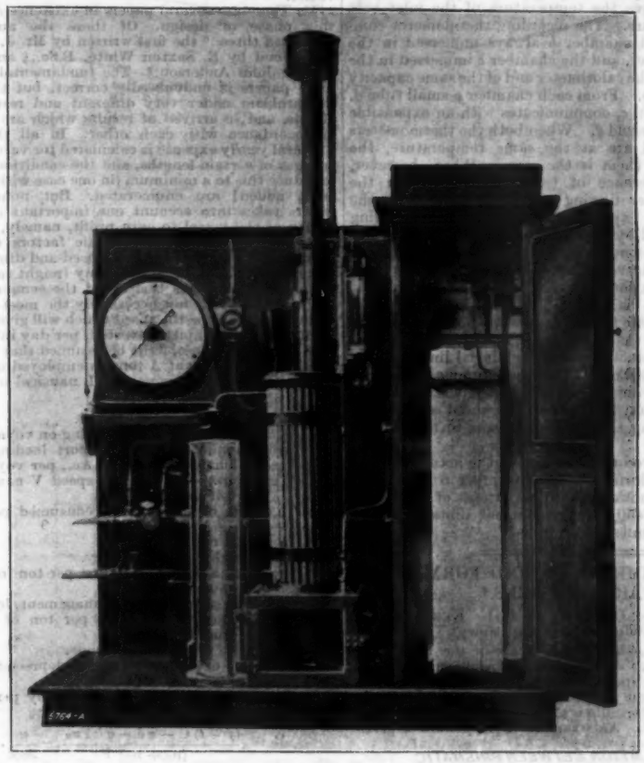
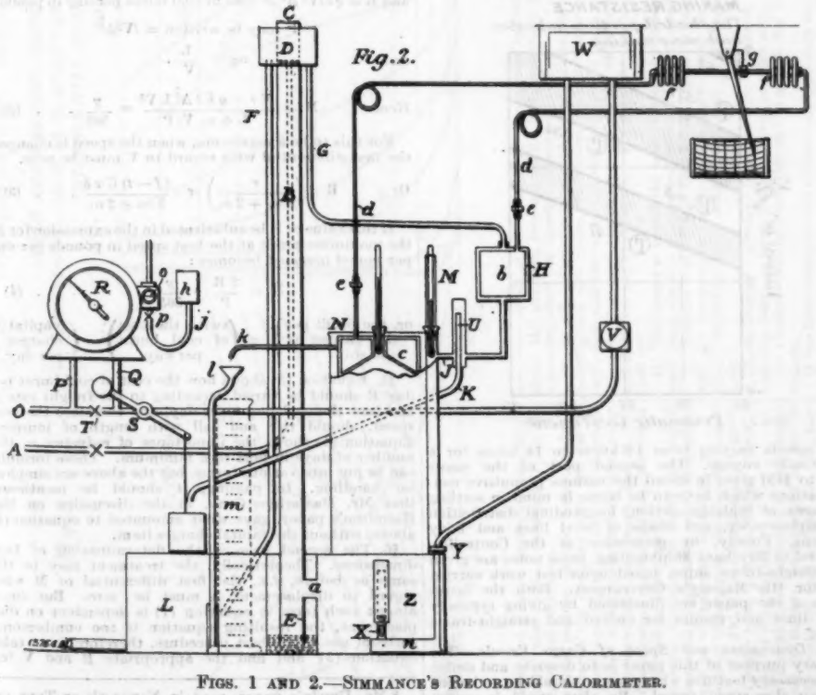
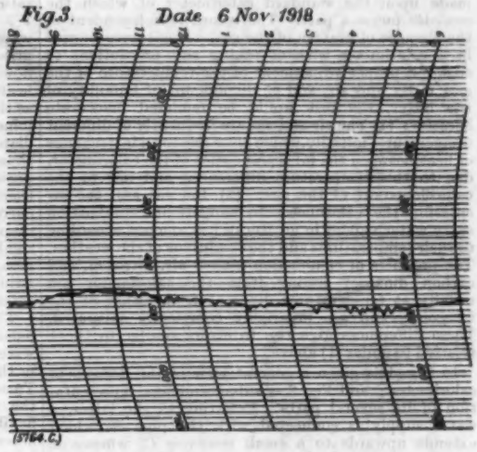


FIG. 1.



FIGS. 1 AND 2.—SIMMANCE'S RECORDING CALORIMETER.



by empirical means, but by automatically imparting heat to water, and recording the heat so imparted; and further, that the chart reading can at any moment, and without interrupting the course of the record, be checked by or compared with an experiment or test made upon the standard calorimeter of which the recorder forms a part. The record is independent of the changes of gravity of the gas. If gas were burned in a calorimeter without taking any precautions to ensure a proper adjustment of the temperature of the gas, water and air, and of the amount of humidity of the latter, the test would be rendered inaccurate because: (1) The air and gas are frequently of different temperatures initially, which gives rise to an interchange of heat between the inlet and outlet of the calorimeter, due to this temperature difference, and not to the calorific power of the gas; (2) the gas and the air entering the calorimeter to support its combustion carry water vapour in greater or less amount according to their temperatures and the conditions of the weather. The products of combustion (excess air, nitrogen, and carbon dioxide) issuing from the calorimeter are usually at temperatures different from either of the foregoing, and are invariably completely saturated. These differences give rise to errors similar to those referred to under (1) above.

In Fig. 1 is given a general view of the total-heat calorimeter; and Fig. 2 is a diagrammatic representation of its several parts. Referring to the latter, a water supply is connected with the pipe A, which extends upwards to a small reservoir C, whence it overflows over weirs in three streams, (1) through fine perforations D in the periphery of the air-saturating tube B, in which the water flows as a thin skin down the inside surface into the tank E; (2) an overflow F; (3) a pipe G which keeps full to overflowing a water-box H containing the cold bulb *b*, of the recording thermometer. From the water-box the water flows through a chamber containing a constant level overflow pipe U, and through pipe J to the calorimeter. From the pipe J the water rises to an open head in a tube, preferably of glass, M, which may contain a thermometer, and thence descends into the calorimeter, where it is heated by the combustion of the gas on its way upwards to a third head, at a level just below the calorimeter lid N, which is not airtight, but only sufficiently closed to prevent undue cooling of the warmed water. From this head it flows around the hot bulb *c* of the recording thermometer to the outlet pipe *k*, which either delivers to a funnel *l* leading to waste, or when this funnel is turned aside, delivers to a measuring vessel for use when a test of the apparatus is being made.

As already pointed out, the arrangement of three heads at F, M and N, each open to atmosphere, permits escape of air in suspension in the water, the last N eliminating the bubbles evolved by heating the water. In this manner constant pressure of water at the entrance to the calorimeter and regularity of flow are secured. Gas enters at O and from this pipe is taken the supply P to the meter R, which is thus by-passed, the gas returning to the pipe by branch Q. Between the branches P and Q is a cock T which, when shut, causes all the gas to pass through the meter and when open leaves the meter drum at rest, the pressure being equal in the two branches. Thus the meter need only be in use during a test, and evaporation of water from it due to a constant flow of gas is avoided.

To avoid damage to the apparatus due to continued burning of the gas when the water supply has been accidentally cut off, there is a cock S on the gas supply, the lever of which is weighted at one end to counterbalance a bucket suspended from the other end. The bucket receives the discharge through pipe K, from overflow U, and delivers it through a perforation in its bottom into the waste tank L. So long as the discharge is flowing the bucket overflows and the cock S remains open; should the discharge cease, the bucket empties itself and the weighted lever turns to close the cock. From this safety cock the gas flows to the governor V to dispose of excess pressure and thence upwards to the governor or container W, which creates a constant head of gas notwithstanding variations in the specific gravity of the gas and in atmospheric conditions. The pipe from this governor is connected with the burner X by a ground-in joint Y, which enables the burner to be swung out for lighting. As the burner box Z is usually at a lower temperature than the outside air, the burner pipe is enlarged at *n* to form a sump to receive any water which may be condensed from the gas. The burner consists of a brass tube on which slides a second tube. The burner is lighted outside the burner-box and is then pushed into the latter until it meets a stop. Then the outer burner tube is raised on the inner one, and turned to engage a bayonet catch. In this way the flame is raised into the calorimeter.

Air for combustion enters at the top of the saturating tube B, the skin of water on the inner surface of which ensures saturation of the air; thus the air enters the burner-box at *a* saturated with water vapour at the temperature of the cold water whatever its hygrometric state before it enters the top of tube B. The products of combustion mixed with excess of air pass up inside the calorimeter and issue through the known exit saturated with aqueous vapour at a temperature about 1·5 deg. C. above the temperature of the inlet cold water temperature. The recording thermometer comprises the closed chamber *b* always immersed in the flowing cold water, and the chamber *c* immersed in the heated water in the calorimeter and of the same capacity as the chamber *b*. From each chamber a small tube *d*, joined by a union *e*, communicates with an expansible diaphragm or aneroid *g*. When both the thermometers thus constituted are at the same temperature, the pressure within them is the same. When, however, there is a difference of temperature between the currents of water flowing round the chambers, the diaphragms are expanded or retracted, and being rigidly connected by a rod the difference between their movements is communicated to the pen coupled adjustably to the rod, and is recorded on the drum rotating by clockwork.

The meter R is preferably constructed to pass one-tenth of a cubic foot of gas per revolution when the water line is such that the bottom of the water meniscus in the gauge *o* coincides with the fiducial line thereon. To adjust this level cocks T and *p* may be opened and the water reservoir *h* connected with the gauge by flexible tube *j* may be raised or lowered as may be necessary to bring the water meniscus to the correct level.

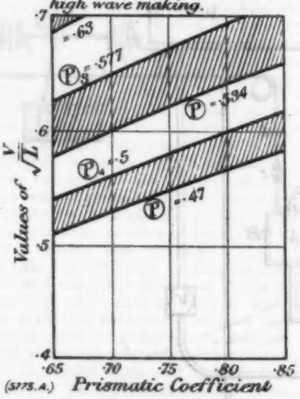
Fig. 3 is a reproduction of one of the actual records taken from a calorimeter on November 6 last, from which it will be noticed that fluctuations of total heat varied between 450 British thermal units and 500 British thermal units.

SPEED, DIMENSIONS AND FORM OF CARGO VESSELS.*

By G. S. BAKER, O.B.E., and J. L. KENT, of the William Froude National Experiment Tank.

§1. *Introductory.*—The paper deals in the first place with the economics of cargo ship propulsion, so far as this is affected by speed and design of hull form. It is shown how the best speed depends upon freight rates, &c., and a simple formula is given from which this speed can be calculated. An example in Appendix I gives

Fig. 1. RELATION BETWEEN PRISMATIC COEFFICIENT, LENGTH AND SPEED FOR HIGH & LOW WAVE MAKING RESISTANCE. The shaded portion indicates high wave making.



best speeds varying from 12 knots to 14 knots for a 4,000-mile voyage. The second part of the paper (§10 to §19) gives in detail the various propulsive considerations which have to be borne in mind in settling the area of midship section, longitudinal distribution of displacement, and shape of level lines and body sections. Finally, by permission of the Controller-General of Merchant Shipbuilding, some notes are given on straight-frame ships, based upon test work carried out for His Majesty's Government. Both the latter parts of the paper are illustrated by giving typically good lines and results for curved and straight-frame ships.

§2. *Dimensions and Speed of Cargo Vessels.*—The primary purpose of this paper is to describe and define the necessary features which can or should be embodied in any slow-speed vessel. By slow speed is meant such a speed as is common with ordinary cargo tramps, and may for the purpose of the paper be more precisely limited to speeds not exceeding, say, 14 knots for a 400-ft. vessel. As the shape of the vessel necessarily depends on its dimensions and speed, it is desirable first to consider these factors and how they should be determined in practice. The only reason for the existence of the cargo tramp is its earning capacity. The efficiency of the vessel must be measured by the amount of profit earned in a given time with a given amount of capital. For this to be high, the dimensions and speed must be arranged to suit the general service conditions of the vessel.

§3. There are several papers in existence dealing with this phase of design. Of these the authors have examined three:* the first written by Mr. J. Hamilton,† the second by E. Saxton White, B.Sc.,‡ and the third by Mr. John Anderson.§ The fundamental idea in all these papers is undoubtedly correct, but they tackled the problem under very different and restricted conditions, and so arrived at results which are not always in accordance with each other. In all these papers the total yearly expense is calculated for various ships or voyages of certain lengths, and the conditions necessary to reduce this to a minimum (in one case with a standard profit added) are enumerated. But none of these papers takes into account one important item in the ability of the vessel to earn profit, namely, the freight rate. This is fixed by economic factors quite apart from ship design, and the best speed and dimensions are those which make the most of any freight rate. It is a misnomer to call this best speed the economical speed of the ship, as it is not necessarily the most economical result in coal. It is the speed which will give the largest profit per pound capital invested, per day invested.

§4. In the first case, let it be assumed that an existing vessel of displacement Δ tons is employed on a service of which the average voyage is L nautical miles.

Let C = cargo deadweight.
δ = net tonnage.
n_s = number of days steaming on voyage.
n_L = number of days in port loading and discharging, repairs, &c., per voyage.
I = i.h.p. of engines for speed V nautical miles per day.
k = No. of tons of coal consumed per day per i.h.p.
q = cost of 1 ton of coal.
f = freight rate of journey.
x = tonnage dues in pound per ton for complete journey.
t = sum of brokerage, management, loading, discharge in pounds per ton of cargo, for complete journey.
P = price of vessel in pounds.
yP = sum of insurance, repair, depreciation, wages per year, in pounds.

Then the rate of earning money per day per pound of capital is:

$$M = \frac{(f-t)\,C - x\delta - q\,k\,I\,n_s}{(n_s + n_L)\,P} - \frac{y}{365} \quad . \quad . \quad (1)$$

Writing $(f-t)\,C - x\,\delta = r$

and $R = q\,k\,l V^3 \Delta^{\frac{2}{3}}$ = cost of coal burnt per day in pounds.

I may be written $= l V^3 \Delta^{\frac{2}{3}}$

and $$n_s = \frac{L}{V}.$$

Hence $$M = \frac{V\,r - q\,k\,l\,\Delta^{\frac{2}{3}}\,L\,V^3}{L + n_L\,V)\,P} = \frac{y}{365} \quad . \quad . \quad (2)$$

For this to be a maximum, when the speed is changed, the first differential with regard to V must be zero.

Or $$R = \left(\frac{r}{3\,n_s + 2\,n_L}\right) \text{ or } = \frac{(f-t)\,C\,x\,\delta}{3\,n_s + 2\,n_L} \quad . \quad . \quad (3)$$

If this value of R be substituted in the expression for M, the maximum profit at the best speed in pounds per day per pound invested becomes:

$$M = \frac{2\,R}{P} - \frac{y}{365} \quad . \quad . \quad . \quad . \quad (4)$$

or, the profit per day earned by the ship $\Big\}$ = (twice the cost of coal burnt per day) − (capital charges per day)

§5. Equation (3) shows how the cost of coal burnt per day R should be varied according to the freight rate f, and how the coal burnt per day, and therefore the best speed, should rise and fall with length of journey. Equation (1) shows the importance of reducing n_L the number of days in port to a minimum. These formulæ can be put into various forms, but the above are simplest for handling. In passing, it should be mentioned that Mr. Macfarlane Gray, in the discussion on Mr. Hamilton's paper, gave what amounted to equation (4) above, without the capital charges item.

§6. The second case is the determination of best dimensions. Theoretically, the treatment may be the same as before, *i.e.*, the first differential of M with regard to displacement Δ must be zero. But since almost each term in equation (1) is dependent on displacement, the resulting equation is too cumbersome to be of use. The best procedure, therefore, is to take equation (3) and find the appropriate R and V for

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, February 18, 1919.

* Mr. Unwin's paper, read in Newcastle-on-Tyne on January 14, 1919, which is on better lines than previous ones, came to hand too late for any specific reference to be made to it.

† Trans. Institution of Naval Architects, vol. xxiv, page 256.

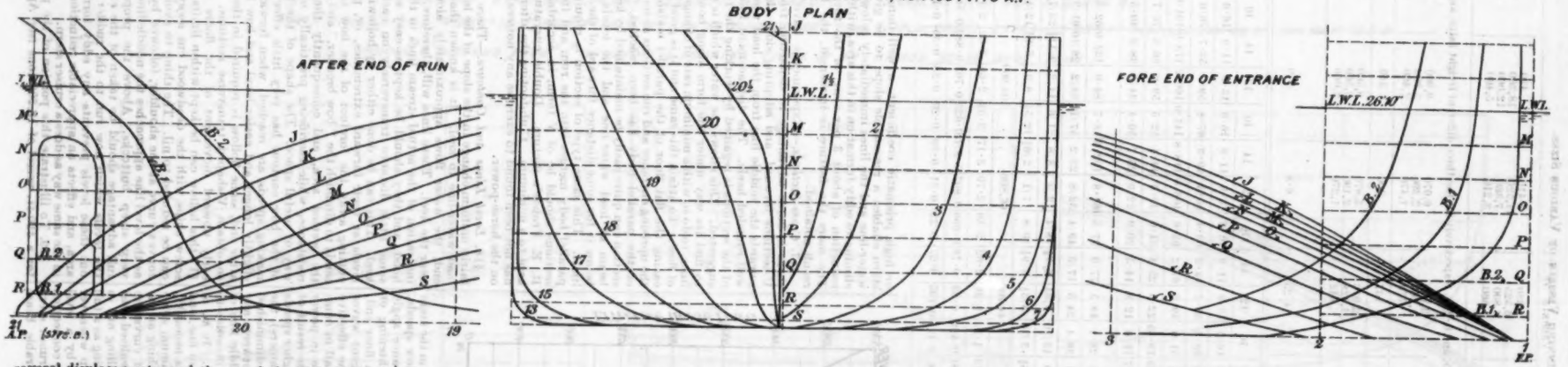
‡ Trans. North-East Coast Institution of Engineers and Shipbuilders, vol. xxviii, page 29.

§ Trans. Institution of Naval Architects, vol. lx, page 23.

SPEED, DIMENSIONS AND FORM OF CARGO VESSELS.

Fig. 2.

LINES FOR A VESSEL WITH CURVED FRAMES (§19) MODEL N°396.
SHIP DIMENSIONS:- 490 FT. (B.P.), 62·75 FT. BEAM, 26 FT. 10 IN. DRAUGHT, 18,200 TONS DISPLACEMENT.
ENTRANCE 147 FT., PARALLEL BODY 147 FT., RUN 196 FT. TO A.P.



several displacements, and then to find which displacement gives the highest value of M in equation (4) for all reasonable freight rates and coal prices.

§7. To illustrate this portion of the paper, and to introduce and familiarise the designer with the use of the formula, the detail working of an example is given in Appendix I. Three widely-different freight rates and five widely-different vessels are chosen, and M, the rate of earning profit per pound capital per day, is worked out for all of them. It will be seen that :—

(*a*) The profit-earning capacity of both the small vessels is very low under all freight rates, and the smallest vessel can sometimes be worked only at a loss.

(*b*) The profit-earning capacity in the longest vessel is not so good as in the 490-ft. vessel for a given price of coal and given freight rate, and the 490-ft. vessel is the all-round best one for this voyage.

(*c*) With a 7*s.* 6*d.* freight rate, the speed of this vessel should never exceed 10 knots; with freight at 10*s.* it should remain at 10 knots for coal at 25*s.* per ton, and rise to 13 knots with coal at 12*s.* per ton; and with freight at 20*s.* it should be at least 14 knots, unless coal is more than 26*s.* 10*d.* per ton.

(*d*) The largest vessel is really suffering badly from the long time taken to discharge and load cargo. This time is taken from Mr. Anderson's paper, and it was pointed out in the discussion on the paper that this was high. If n_6 is reduced, R is increased, and the maximum profit-earning will also be increased.

(*e*) It will be understood that for shorter or longer voyages the results may be different. This can be seen by varying n_6 in equation (3) for R. A shorter journey increases the best speed for a fixed price of coal, but the amount would depend upon several circumstances.

(*f*) By putting $2R = \frac{yP}{365}$ the condition for working at no profit is obtained, R being defined here by formula (3).

§8. The cost factors *x*, *t*, *y* and P, are all known with fair accuracy for vessels employed on fairly regular trade, and although *q*, *t* and P are liable to vary, they are quite definite, and it is a comparatively easy thing for any designer to find the limiting speed appropriate to average limiting values of freight rate *f* and coal value *q*. The vessel should be designed to obtain the highest speed appropriate to these average values. With a good form the propulsive efficiency will then always be good at lower speeds, and good profit returns will result. If the design is arranged for average speed for average freight rate and coal price, the vessel may lose some or all of the advantage of any rise in freight above the average, because of its bad propulsive performance when the speed is increased.

§9. In all calculations of this kind, a number of assumptions are made, and some known factors are neglected, and due weight should be given to these when selecting the speed for any voyage or the displacement and speed for any trade route. For example, it is known that :—

(1) The larger a vessel the more seaworthy it can be made, and the less is its speed affected by bad weather.

(2) Reserve coal to meet bad weather must be carried, and the proportion which this reserve bears to the whole decreases both with speed and with displacement.

(3) Relatively greater facilities are required for handling cargo in large vessels than in smaller ones.

(4) Greater coaling facilities are required for large vessels.

It has been assumed that all the vessels on each voyage have full cargoes. Loss of cargo is equivalent to smaller *r*, and therefore reduces R, *i.e.*, tons of coal burnt per day, which means running at less than full profit. It would be necessary to work this out in detail to tell whether the large or small vessel is most affected, but presumably the larger one is most liable to run under these conditions, as it deals with larger weight of cargo.

(5) The assumption that the indicated horse-power varies, as the cube of the speed does not hold good for many cargo vessels now built, or for any ordinary cargo vessel if it is forced to speeds in the region of 14 knots (on a length of 400 ft.). The formula will in this case overrate the proper speed to a certain extent.

§10. *Ship Dimensions.*—It will be seen from the foregoing that actual dimensions do not enter into the problem of the earning capacity of a ship, except as they affect deadweight, displacement and economy of propulsion. Two at least of the principal ship dimensions, namely, length and draught, are so involved with port facilities that in many cases these facilities, and not propulsion at all, define what is possible with both length and draught, and the naval architect's usual problem is to produce the least resistful form of given displacement without altering these dimensions. At this stage it would be useful to state the various forms of resistance which a cargo vessel experiences and their relative magnitude. At quite low speed there is a small amount of wave making, a little eddy formation, and a great deal of skin friction. The latter amounts to about 80 per cent. of the whole. At higher speeds, *i.e.*, at what might be called the limiting practical speed,* the skin friction should be about 70 per cent. to 75 per cent. of the whole, and the wave making most of the remaining 30 per cent. to 25 per cent. But in all tramps there is a small amount of eddy formation on the upper levels at the stern near the body post; this point is dealt with later (§15 and §16). The waves created consist of divergent sets at each end, and transverse waves. Economy in wave making can be affected by so arranging the shape that the bow transverse waves tend to cancel the stern transaverse waves at such speeds as these may be important.

§11. *Wetted Surface.*—The smaller the wetted surface per ton of displacement is kept, consistent with non-wave-making, the better will be the propulsive performance. Calculations have shown that this is remarkably non-sensitive to such factors as proportion of parallel body in length, and prismatic coefficient, but depends mainly upon the cross dimensions. With fixed beam, the wetted surface per ton will drop steadily as draught is increased, and a similar drop is obtained if draught is fixed and beam increased. The best ratio of beam to draught is that which gives precisely the same reduction of skin per ton for either beam or draught variation. In Appendix II a formula for this ratio has been obtained in the case of a simplified ship form. This formula has been compared with results obtained by calculation for a number of models whose principal dimensions have been widely varied, and found to give results about 6 per cent. high, with parallel body from 25 per cent. to 50 per cent. of the length. The ratio given by the formula must be regarded as a sort of datum. When the $\frac{\text{beam}}{\text{draught}}$ of a ship is materially less than that given by the formula (corrected for the above 6 per cent.), there is something to be gained by increasing beam and decreasing draught. When the displacement is constant and the ratio $\frac{\text{beam}}{\text{draught}}$ is near that obtained by the formula, it may be changed to a quite fair extent without any variation of wetted surface. As a matter of interest, this ratio is about 2·8 for some tank forms of 30 per cent. parallel body, and somewhat less than this for forms of 50 per cent. parallel body. These proportions require to be borne in mind in settling the shape of midship section.

§12. *Midship Section Area and Shape.*—The displacement and length being fixed, the settlement of these items is the first step in lining out the form. For a given speed and displacement there is a midship-section area most appropriate for low wave-making resistance. This area A can be found from the simple formula :

$$A = \frac{6{\cdot}29\ \Delta\ P^2}{V^2} \text{ sq. ft.}$$

Where V is the speed in knots, Δ is the displacement in tons, and P^2 is a wave-making constant. Most appropriate limits to the values of P^2 for low wave-making can be obtained from Fig. 1, in which the unshaded portions give minimum resistance.

Putting these values of P in the above equation, the limiting values of A are obtained.† Experiments on models with different midship-section coefficients‡ point to the employment of the largest possible midship section consistent with the other features of the design in vessels of this type, and this conclusion is supported by the general test work of the Froude tank.

With vertical sides from the load water-line to from 4 ft. to 5 ft. above the keel, associated with a very small rise of floor (or none at all) and a bilge curve of radius of from 4 ft. to 5 ft., a coefficient of 0·98 can be obtained. From an economical propulsion point of view, a rise of floor has the one advantage of permitting easier bow and buttock lines to be worked when there is a considerable amount of parallel middle body, but if a larger radius of bilge and quite flat floors are used, equally good results can be obtained, and it has been found possible, by careful design of the ship at the sections where the entrance and run join the parallel body, to work a square corner to the midship section without any appreciable loss in effective horse-power. Such a shape abolishes the need for a bilge keel, but may present difficulties in constructional design and in

* *i.e.*, The highest speed possible without any abnormal increase in $\frac{\text{resistance.}}{\text{(velocity).}}$

* The origin and meaning of this constant are given in Trans. Institution of Naval Architects, vol. lv, Part II.

† For a 490-ft. vessel of 18,200 tons at 12 knots, or $\frac{V}{\sqrt{L}} = 0{\cdot}54$ the prismatic coefficient should be above 0·73, to give P a little less than 0·471. That taken for Fig. 2 is 0·77.

‡ Trans. American Society of Naval Architects and Marine Engineers, 1901. D. W. Taylor.

practical use. The shape of section being settled, and the draught being already fixed by port facilities, the beam must be arranged to give an area of section A inside the limits already calculated, or as near as possible to these. It should be noted that, as soon as this is fixed, the prismatic coefficient is similarly fixed and the wave-making characteristics are determined. When it is thought desirable, the aim of this section can be achieved by the tentative process of assuming midship area, length, and prismatic coefficient, and seeing what P value is obtained and how this comes on Fig. 1. If it is in a bad place the assumed data should be adjusted.

Longitudinal Distribution of Displacement.—The next step is to decide upon the most economical longitudinal distribution of displacement which, while giving a reasonable position for the longitudinal C.B. will require the minimum horse-power.

§13. *Parallel Middle Body.*—It is generally advantageous, both from the point of view of space and of low cost of construction, to work as much parallel middle body as possible. To determine the greatest length of perfectly parallel body, consistent with low residuary resistance at the required speed, reference can be made to the papers* giving results of experiments made at the William Froude National Tank. These papers deal with experiments on models of ships of the average dimensions of tramp steamers, and by choosing the set of experiments on models nearest in prismatic value to that already settled (§12) a very fair estimate can be made of the greatest percentage length of parallel middle body to be safely used for the service speed. Similar experiments carried out by Mr. Taylor support these results, and our work of the last few years shows that they can be used with confidence. For vessels of greater or less proportion of beam to length than is usual, the results may be slightly different. The result of an investigation of beam effect will be presented at the spring meetings of the Institution of Naval Architects this year. In passing, attention might be drawn to the very large waste of power that may result from a bad selection of length of parallel for a given speed in short full ships. This is very clearly shown in the classical experiments of Dr. William Froude, Transactions of the Institution of Naval Architects, and the Teddington tank parallel-body series "J" and "K" described in the Transactions of the Institution of Naval Architects, vol. lvii.

§14. *Ratio of Length of Entrance to Length of Run.*—When the percentage length of perfectly parallel body has been settled, the relative amounts of the remaining length of the ship which can be put into entrance and run should be determined. Complete experiments† made at the William Froude National Tank, covering a range of prismatic coefficient of 0·85 to 0·66 with 10 per cent., 30 per cent. and 50 per cent. of parallel middle body, enable a close estimate of the best ratio to use for the particular speed at which the ship is to run, in order to get minimum horse-power. For high proportions of parallel body (50 per cent.) an $\frac{\text{entrance}}{\text{run}}$ of about 0·9 is best, and there is a small advantage in working the entrance shorter than the run even with 30 per cent. parallel middle body. The prime cause of this advantage in a low ratio of $\frac{\text{entrance}}{\text{run}}$ is the avoidance of eddy-making at the stern by the longer run obtained, and provided this is attained, the resistance is not very sensitive to this ratio, and this permits of a certain amount of freedom in adjusting the longitudinal C.B. Tank experiments have shown that for vessels of ordinary proportions the minimum length of run required is given by $4 \cdot 1 \sqrt{\text{midship section area}}$ (see also §16).

§15. *Prismatic Coefficient of Entrance and Run and Curve of Areas of Sections.*—The designer is now in a position to draw the curve of areas, which will satisfy the length of entrance, run and parallel body, and the prismatic coefficients and displacement already fixed. He will probably prefer to base the first rough shape of the area curve on that of some particular ship not greatly different in dimensions, whose trial results he may have. Guidance as to the best modifications to the form of this curve can be obtained from the published results of model experiments made at the William Froude National Tank and by Taylor and Sadler, in order to determine the effect of change in prismatic coefficient and shape of the ends. The results of the tank experiments can be found in sets F, G and H, Transactions of the Institution of Naval Architects, vols. lvi and lvii. Generally speaking, (*a*) a somewhat full shoulder to the entrance is not detrimental if the speed is low, but a full shoulder to the run may result in an increase in power, due to either eddy or divergent-wave formation. (*b*) The after end of the run should not be cut away to get a fine finish, but the area curve should be carried out with a fair curve to its end, with no marked change in shape just before the body post. (*c*) Every endeavour should be made to avoid a quick change in the slope of the tangent to the curve, and the maximum slope of this tangent to the base should be kept as small as possible. (*d*) When the prismatic coefficient is below 0·7 and the speed above P = 0·5 (i.e., 11·2 knots for a 400-ft. ship) the curve of areas of sections of entrance should have a little hollow in it, and this should die out altogether for a prismatic coefficient of 0·8 at all speeds.

§16. *Load Water-Line.*—For all tramp steamers this should have a slightly convex or straight entrance. The shoulder of the fore end where it runs into the parallel body can be fairly blunt if necessary. The higher the speed required, the finer must the entrance angle be made, and the greater must be the distance from the stem before it turns into the parallel body. At low speeds, say 9 knots for a 400-ft. ship, 60 deg. entrance angle (side to side) can be accepted. By straightening or hollowing the load water-lines to produce a finer end, a lower "bow breaker" and smaller divergent waves are formed. Yet it does not follow that the effective horse-power will be lower if the speed is small in comparison with the ship's length. An increase in power of from 4 per cent. to 5 per cent. may be the result of working a hollow line forward, although at higher speeds (usually beyond the limits of tramp steamers) the influence of the finer end always shows itself in diminished resistance. At the after end, the angle between any tangent to the load water-line and the middle line of the ship, should not exceed about 20 deg. in order to avoid dragging dead water with the vessel. It is, of course, not always possible to keep the line so fine, and should a greater angle than 20 deg. become a necessity, the curve must be so drawn that the maximum slope is as far aft as possible, consistent with finishing at the rudder post without any marked change of curvature or hollow in the curve. It is not generally realised that at low speeds a fine end aft, obtained by filling out in front of it, is quite as conducive to eddy-making as a full finish, as the stream-lines tend to break up whenever the rate of expansion exceeds that given by a level boundary of 20 deg. to 25 deg. It is in this connection that the main propulsive advantage of a cruiser stern is obtained. With ships of either considerable beam or high prismatic coefficient, a well immersed cruiser stern enables a reasonable slope to be given the load water-line and the lines immediately below it, and thus eliminates eddy-formation in this area, with a consequent reduction of about 3 per cent. of the total resistance. The more the feature is immersed, the better is the result obtained.

§17. *Cross-Sections.*—Experiments have shown that there is some advantage in departing from the usual U-sections forward, and adopting sides sloping inward towards the middle line from the load water-line, with well-rounded heels. The displacement lost at the heel of the sections is regained by working the full water-line suggested. This allows the water which is endeavouring to find its way under the form along bow or diagonal lines, to do so with a minimum rate of change of curvature of flow. To attain this same end it is good to commence easing the flat floor of the parallel midship body into the uprising entrance and run sections as soon as the limit of the parallel body has been reached. The area of section can quite easily be maintained by keeping the full beam at load water-line and the levels immediately below it for some distance forward of the parallel-body limit. This same type of section is required where the parallel body merges into the run, and further aft the sections should be of V form, in accordance with Mr. R. E. Froude's dictum. Double curvature should be kept to a minimum. Club-footing the aftermost sections has not been found to exercise any noticeably bad effect on the horse-power.

§18. *Level Lines and Contours.*—There should be a fairly uniform change in the slope of the level lines from load water-line to keel. It is known that, at the fore end, the water flows approximately along bow lines near the keel. These lines will, therefore, give the best indication of the actual stream lines in this neighbourhood, and they should be kept as easy as possible for some little distance transversely on each side of the keel. This can be done either by hollowing the lowest levels at their forward extremities, or, preferably, by cutting away the forefoot of the bow contour. This tends to diminish the "bow breaker," and also decreases the wetted area, and consequently the skin-friction resistance, while sacrificing practically nothing in the way of useful space. The shape of the upper portion of the bow contour has very little effect until wave-making speeds are reached, when forward rake gives slightly longer and easier level and bow lines. At the after end, some hollow is required in the lowest levels to obtain V-shaped transverse sections, but with the early upward movement of the floors mentioned in §17 this hollow can be kept within limits, and in twin-screw ships with the deadwood cut away at the post, can be reduced to nil. The thing to avoid is a marked convex curve at the shoulder, followed by a steep slope as the level line approaches the middle line, as this gives very steep buttocks. Above the propeller aperture full advantage should be taken of the extra length of the levels which now run to the rudder post. Filling out these levels prevents any eddy formation in this area, and effects an appreciable reduction of resistance in the same way as does a cruiser stern.

§19. To illustrate this portion of the paper a design for a 400-ft. vessel of 18,200 tons (see Appendix I) has

* Trans. Institution of Naval Architects, vols. lvi and lvii.

† Trans. Institution of Naval Architects, vol. lv.

EXPENSES OF RUNNING VESSELS OF VARIOUS SIZES.

Ship length, L in feet	250	330	410	490	570
Displacement, Δ in tons	3,030	6,525	11,520	18,360	27,310
Cargo deadweight, C in tons	1,390	3,890	7,360	12,000	18,360
Net tonnage, *s* in tons	700	1,660	3,210	5,400	9,780
Since $t = 0 \cdot 175 (f - t)$ becomes 0·825, 0·325, and 0·2 lb. respectively for the three different freight rates, and					
$(f-t)C$ with f = 20/–	1,147	3,110	6,070	9,900	15,160
with f = 10/–	452	1,265	2,390	3,900	5,980
with f = 7/6	278	770	1,470	2,400	3,685
$x\,s$ where x = 1/3 per ton	44	137	260	340	610
$(f-t)$ with f = 20/–	1,103	2,973	5,870	9,560	14,550
$(C - x\,s = r)$ with f = 10/–	408	1,128	2,190	3,560	5,370
with f = 7/6	234	642	1,270	2,060	3,075
Number of days to unload and load, including percentage for repairs for each voyage = n_1	2·5	4·25	6·8	9·0	13

With V in knots =	8	12	10	10	12	14	10	12	14	10	12	14	10	12	14	
n_2 =	20·8	13·9	16·6	16·6	13·9	11·9	16·6	13·9	11·9	16·6	13·9	11·9	16·6	13·9	11·9	
$3\,n_2 + 2\,n_1$ =	67·4	46·7	54·8	58·3	50·2	44·2	63·4	55·3	49·3	67·8	59·7	53·7	76·9	67·7	61·7	
$\frac{r}{3\,n_2 + 2\,n_1} = R =$ f = 20/–	16·4	23·7	20·1	51·0	59·2	67·2	92·6	106·0	118·8	141·0	160·2	178·0	191·6	215·0	236·0	
f = 10/–	6·05	8·74	7·45	19·35	22·5	25·4	34·6	39·6	44·4	52·5	59·6	66·3	70·7	79·4	87·0	
f = 7/6	3·47	5·0	4·27	11·0	12·8	14·5	20·0	22·9	25·7	30·4	34·5	38·3	40·5	45·4	49·8	
Estimated coal burnt per day, in tons =	15·5	33·4	19·3	28·1	48·5	77·0	37·5	64·8	102·6	48·7	84·0	133·0	62·5	108·0	171·0	
Corresponding £ or cost of coal in shillings and pence per ton f = 20/–	21/2	14/2½	20/1	36/4	24/5	17/5	49/4	32/8	23/2	57/10	38/2	26/10	61/3	39/10	26/7	
f = 10/–	7/9½	5/3	7/9	13/10	9/3½	6/7½	18/4	12/3	8/8	21/6	14/2	9/11½	22/7½	14/8½	10/2	
f = 7/6	4/6	3/–	4/5½	7/10	5/3½	3/9½	10/8	7/1	2/6½	12/5½	8/3	5/9½	12/11	8/5	5/10	
Capital cost in pounds (P) =	26,760			44,700			66,800			104,900			153,700			
Profit per pound per day, f = 20/–	0·85	1·4	1·13	1·9	2·26	2·62	2·39	2·79	3·17	2·31	2·68	3·02	2·11	2·42	2·69	
$M \times 1000 = \left(\frac{2n}{P} - \frac{y}{365}\right)$ f = 10/–	0·076	0·227	0·181	0·489	0·63	0·76	0·658	0·807	0·951	0·623	0·763	0·889	0·545	0·655	0·757	
f = 7/6	–0·12	0·0	0·06	0·115	0·195	0·27	0·22	0·31	0·39	0·20	0·28	0·35	0·15	0·215	0·27	

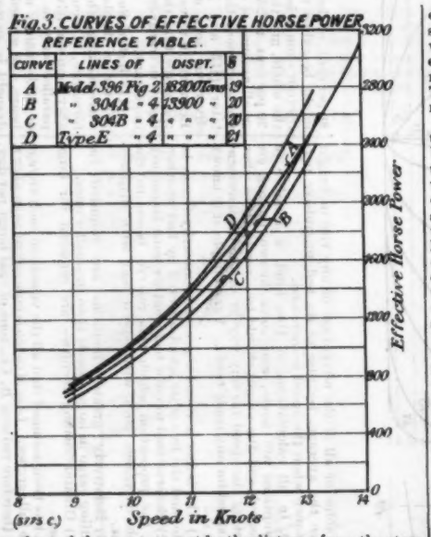
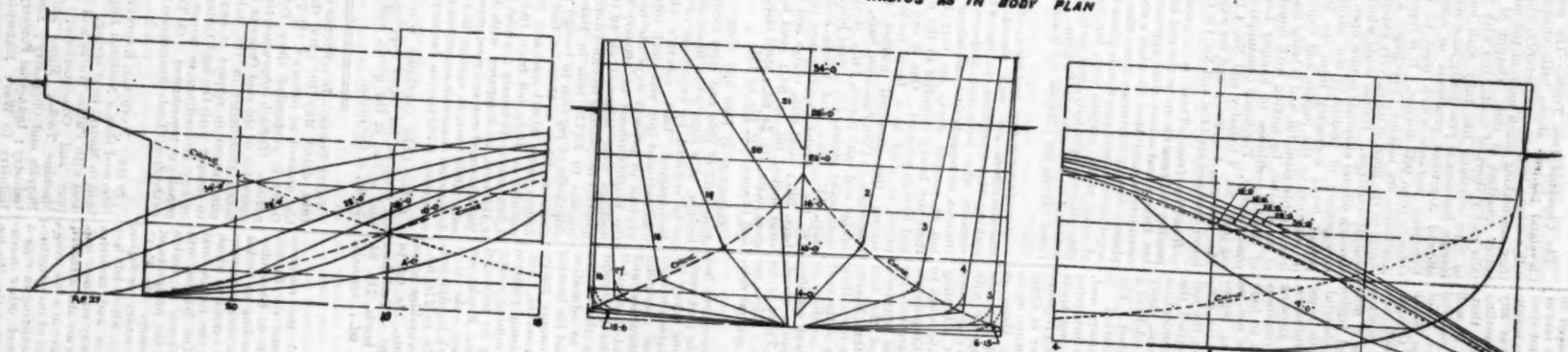
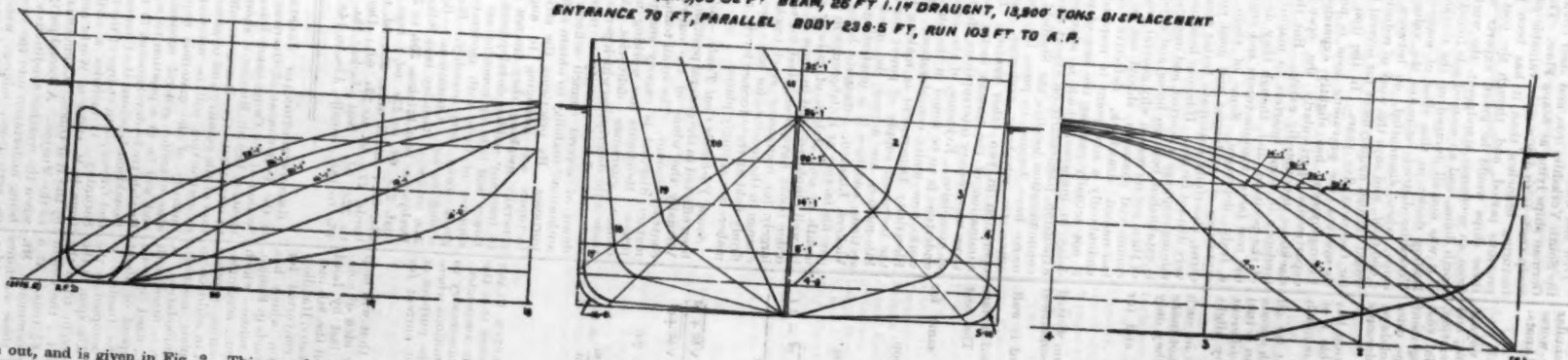


Fig. 4. LINES OF STRAIGHT FRAME VESSELS; NATIONAL TANK MODELS NOS 304 A & 304 B.
SHIP DIMENSIONS - 411·5 FT (B.P.), 55·5 FT BEAM, 27 FT 4 IN. DRAUGHT, 18,000 TONS DISPLACEMENT, ENTRANCE 106·5 FT, PARALLEL BODY 185 FT, RUN 180 FT TO A.P.
MODEL "B" DIFFERS FROM "A" IN HAVING A ROUNDED CHINE OF 4 FT RADIUS AS IN BODY PLAN



MICHIGAN TANK MODEL TYPE E
DIMENSIONS 411·5 FT (B.P.), 55·52 FT BEAM, 26 FT 1.19 DRAUGHT, 13,900 TONS DISPLACEMENT
ENTRANCE 70 FT, PARALLEL BODY 238·5 FT, RUN 103 FT TO A.P.



been drawn out, and is given in Fig. 2. This vessel is required to steam at a maximum speed of 14 knots when the freight rate is high, and at 10 knots when freight is low and coal high, Appendix I, &c. The prismatic coefficient taken is 0·77. This evades wave-making up to about 12·3 knots P = 0·471, and gives a midship area of 1,670 sq. ft., corresponding to a beam of 62·75 ft. and draught of 26·83 ft., the rise of floor being nil. Of the total length 30 per cent. has been made perfectly parallel middle body. The ratio of length of entrance to run has been taken = 0·75, this gives a length of run = 196 ft., and entrance 147 ft. The angle of entrance of the load water-line has been fixed at 55 deg., and all the bow sections cut away at the heel, the curve of areas of sections having only a very slight hollow in it. This cutting away has involved the contour of the stem being raised to avoid hollow lines. At the stern the load water-line is 29·5 deg. The sections have been lifted at the heels as soon as possible aft of the parallel body, and the form has been filled out above the propeller aperture. The curve of effective horse-power for this form is given in Fig. 3. It should be noted that this design is given to illustrate general principles, and that careful consideration is required before it is adopted for conditions other than those assumed. For example, its propulsive efficiency is falling off at 14 knots, and rapidly diminishes at higher speeds.

§20. *Straight-Frame Ships.*—This type of vessel only differs from that considered in the preceding paragraphs in having the sections built up of straight lines instead of curves. The same considerations apply with little qualification to this type as to the other. One additional matter, however, required attention, namely, the run and number of the chine or knuckle lines. A variety of forms of this type have been tested at the tank to the order of the Deputy-Controller of Auxiliary Shipbuilding, and the Controller-General of Merchant Shipbuilding, and the authors are indebted to Lord Pirrie for permission to publish the following data derived mainly from such experimental work. The run of the chine, particularly in elevation, is a most important factor. This can be so adjusted that the resistance for the form is within a few per cent. of that of the curved section ship. With a single chine form, i.e., one in which the side frames and floors meet at a sharp angle with no attempt to bevel or round the joint, this excess resistance can be reduced to about 6 per cent., or with allowance for bilge keels, which are not necessary on the single chine form, to 3 per cent. or 4 per cent. With the chine bevelled away throughout the form, giving a double-chine line, a slightly better result can be obtained. This excess resistance is due to a small amount of eddy formation at the chine. Several single-chine forms have been tested with the sharp angle of the sections replaced by curves of 4-ft. radius throughout, and these gave a performance of the same as for the ordinary curved-section type. The lines for a vessel of this type are given in Fig. 4 and the results in Fig. 3. A form similar to this, with sides carried down to the keel line, and having a sharp angle at the joint, gave results some 60 per cent. worse. Lifting this knuckle to an increasing amount towards the ends steadily improved results, until a line, as given in Fig. 4, was reached. It was also found that, as for the curved-frame ship, that the rise of floor should increase as soon as possible in entrance and run, but the sides may be kept to full or water-line beam for some little distance into entrance and run.

§21. Similar tests have been made with models in the American tanks, and a number of results have been published. In Fig. 3 is reproduced the effective horse-power curve for the Michigan tank, type E,* a model of approximately the same dimensions and displacement as Model 304. The lines of this model are given in

*This is the best form, for which complete data were published by Mr. Saunders in August, 1917. Professor Sadler has published (in November, 1918) some results for a form Y &c, which appears to be better in performance, but the data are not sufficiently complete to enable a definite statement to be made.

Fig. 4. A form of about the same relative dimensions, but of a different type (developed in the Washington tank) having Y after sections and marked U sections with vertical sides forward, gave results very similar in power to the Michigan model, being slightly worse at 8 knots and 2 per cent. or 3 per cent. better at 12 knots.

APPENDIX I.

To find the best speed and displacement for a voyage of 4,000 miles, when the freight rate is 20*s.*, 10*s.*, and 7*s.* 6*d.* per ton, capital charges as insurance, depreciation, repairs, &c., per year being one-seventh initial cost ($y = \frac{1}{7}$), loading, discharge, brokerage and management charges 3*s.* 6*d.* per ton ($t = 0{\cdot}175$ lb.), tonnage dues 1*s.* 3*d.* per ton. Delays for coaling, repairs, holidays, &c., and coal consumed taken as in Mr. Anderson's paper.

For the purpose of the example, the calculation has been made for the five vessels, as used in Table I of Mr. Anderson's paper, and as a result the table is much larger than would ordinarily be required.

Cargo deadweight C has been taken constant for all speeds, but actually would be a little less at high speeds than at low. This could easily be set right in an actual ship, but it makes little difference in comparing different ships, and if necessary could be corrected by slight adjustment of the M value in the last line.

It should be noticed that even fair changes in such items as time for loading and repairs, &c., will not make a serious change in comparative results, *i.e.*, they only want fixing approximately.

For further remarks on the table see §8, and for definition of symbols see §4.

APPENDIX II.

Best ratio of beam to draught for minimum wetted surface per ton displacement, for solid of geometrical form.

The solid is shown in plan in the figure, and is wall-sided of draught "a" feet.

The displacement $\Delta = 2\,a\,b\,(l + c)$ the wetted surface "S" $= 2\,(a + b)\,l + 2\,b\,c + 4\,a\,\sqrt{b^2 + c^2}$. The best dimensions are those for which $\frac{d\,\frac{S}{\Delta}}{d\,\Delta}$ is the same for change of Δ either by beam or draught variation.

$$\text{For a change } \frac{d\,\frac{S}{\Delta}}{d\,\Delta} = -\frac{1}{2\,a^2\,b\,(l + c)},$$

$$\text{for } b \text{ change } \frac{d\,\frac{S}{\Delta}}{d\,\Delta} = \frac{4\,b^2}{\sqrt{b^2 + c^2}} - 4\,\sqrt{b^2 + c^2} - 2\,l \Big/ 4\,a\,b^2\,(l + c)^2$$

and for these to be equal

$$\frac{b}{a} = \frac{2\,\sqrt{b^2 + c^2} + l - \frac{2b^2}{\sqrt{b^2 + c^2}}}{(l + c)} = \frac{2c^2 + l\,\sqrt{b^2 + c^2}}{(l + c)\,\sqrt{b^2 + c^2}}$$

For a box, *i.e.*, blunt ends, $\frac{\text{full beam}}{\text{draught}} = 2{\cdot}0$.

For a form with no parallel body $\frac{\text{full beam}}{\text{draught}} = 4 \left\{1 - \frac{1}{3}\left(\frac{\text{beam}}{\text{length}}\right)^2\right\}$.

SUSPENSION OF THE ELECTRICAL CONVERTER PLANT ORDER.—The Minister of Munitions announces that the Converter Plant Order of April, 1918, is suspended. Until further notice, therefore, it will be unnecessary to obtain any permit from the Minister of Munitions where it is desired to erect any machinery for the purpose of transforming alternating current to direct current for the purpose of electric supply.

COMMERCIAL AVIATION.—An exhibition that will help to familiarise the general public with the idea of commercial aviation was opened on Monday last by Lord Morris, at Messrs. Selfridge's stores. Until the 8th inst. there will be on view a fuselage of one of Messrs. Handley-Page's twin-engine bombing machines converted for passenger carrying. The fuselage shown, which has previously seen much service on bombing raids in France, is now fitted with a tastefully decorated saloon, which provides comfortable, not to say luxurious, accommodation for 17 passengers, and also carries another passenger in an open cockpit in the nose, in addition to a pilot and assistant pilot. The complete machine, which, except for the passenger accommodation, is similar to the firm's well-known bomber, is fitted with two Rolls-Royce engines, each of 350 h.p., fixed between the main planes, and these give it a speed of about 100 m.p.h. The extreme length of the fuselage is 62 ft. 6 in., and about one-third of this is occupied by the saloon, the height of which is 6 ft. 6 in. The span of the upper main plane is 100 ft., and the height from the ground to the top of the king post is 23 ft.; the weight of the machine, fully loaded, is about 6½ tons. At a luncheon which followed the opening ceremony, Mr. Handley-Page stated that a number of these machines were now ready for use, and would be put into service, carrying passengers to the Continent as soon as the Air Convention, now under consideration at Paris, is signed. A new company, he said, had been formed for the purpose, and eventually he hoped to be able to convey passengers and goods to all parts of the world.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Considerable interest is displayed in the South Yorkshire iron and steel circles in the fate of German ships lying at Scapa Flow. The iron and steel scrap trade is to-day a more valuable adjunct to manufacturing branches than it has been perhaps at any previous period, and, though the cost of dismantling these ships would be great, experts are agreed that, from an economic standpoint, the work would be well worth doing, and an assured sale found for the material if it was not all dumped on the market at once. The leading dealer in this class of material in the South Yorkshire district estimates the value of the German ships, when dismantled, at between 1,000,000*l.* and 2,000,000*l.*, and says the work of reducing them to scrap would furnish employment for several hundreds of men for the next five years. In the iron and steel trades themselves, the prevailing tone is not very cheerful. Unemployment has slightly expanded, and in some departments, particularly the open-hearth furnaces, slackness undoubtedly exists. But there is a growing tendency in some quarters to magnify the seriousness of the position, and, though they do not seek to hide the real facts, manufacturers and engineers are not, as a body, depressed. Some of them, including representatives of the largest and most comprehensive concerns, cheerfully anticipate better conditions in the not very distant future. If labour becomes more settled, the mining stoppage is averted, and improved communication is established both on home and export account, many of them see no reason why general prosperity, solely of a commercial character, should not be established. The last-named drawback, defective communication, is undoubtedly a sore point in responsible quarters, and, if not actually causing the loss of orders, is involving delay in inquiries, which is adversely affecting trade expansion, particularly on export account. To improve communication locally, the Sheffield Chamber of Commerce have decided to press for the institution of an automatic telephone exchange, similar to those in operation in two other centres. It is felt that the elimination of the human factor would dispense with those unnecessary interruptions which are the chief cause of complaint. Evidence of the existence of a healthy undertone is to be found in the numerous extensions to works now under consideration. Sheffield Corporation Electricity Department is making big preparations for the increased supply of power for industrial purposes. File-makers are among the most active of the tool sections, and here it is interesting to note that Messrs. Vickers, Limited, anticipate being able to open their new file factory at Hillsborough in the course of the next month or so. Makers of railway material continue to be well employed, and in some of the tramway sections order books have been filled for several months ahead, largely for manganese steel track work. There is no change in the markets for basic steel or iron. Prices are firmly held at their former levels, and as a general rule, makers are strongly placed.

South Yorkshire Coal Trade.—Little improvement has been effected in the general position during the past week. Virtually the whole of the output is going away on contract account. The small tonnage available for open market disposal is eagerly snapped up at maximum prices. Merchants are working under difficulties, and cannot guarantee deliveries. A "hand-to-mouth" trade is the description which perhaps best fits the current situation. Local scarcity is indicated in the closing down of several council schools owing to education authorities' inability to obtain sufficient fuel for heating purposes. By practising the strictest economy manufacturers are managing to augment reserves, but, generally speaking, they are not in the strong position to face any sudden development in the mining world. Power and lighting concerns are pressing for increased supplies of fuels with moderate success. Slacks are going away very steadily. Blast-furnace coke is a strong market. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.* 6*d.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

RECONSTRUCTION OF SERBIA.—Under the auspices of the Department of Overseas Trade and the British Section of the Commission Internationale de Ravitaillement, a British Mission is shortly proceeding to Serbia to investigate the damage resulting from enemy occupation of the country and to ascertain the extent to which reconstruction will be necessary, and the nature and quantity of the materials required. The Mission will also examine general economic conditions in Serbia and will be in a position to report on the prospects of British trade development in that country. Mr. E. C. Donaldson Rawlins, the Commercial Secretary for Serbia and Greece, is in charge of the first party, which left last Saturday. It includes a civil engineer and architect from H.M. Office of Works and a railway engineer lent by the War Office. Commercial experts are also attached to the Mission. A second party will leave in a few weeks when the weather conditions will permit of investigation being undertaken into the conditions existing in regard to agriculture, mining, waterways and other reconstruction problems. It is anticipated that the Mission will remain in Serbia for about two or three months. The functions of the Mission do not embrace questions dealing with relief, which are being arranged by the Supreme Council on Supply and Relief meeting in Paris.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The position as regards Cleveland pig-iron shows little change. Furnaces are still working very unsatisfactorily, with the result that they are making much more of the inferior than of the better qualities of iron. Output of foundry pig-iron falls vastly short of needs, and with supply insufficient to cope anything like fully with home requirements, foreign business is practically at a standstill. This has allowed American producers to come in and supply European markets which used to be served almost entirely from this district. It is reported here that the Americans are making Copenhagen a large distributing centre in the hope of doing very extensive business with neutral countries. Italian trade which has been passing through official channels is now open to merchants, but arrangement of credits is not easily made, a special permit being necessary from the Italian Government in addition to the import and export licenses. Forge iron is quite plentiful, and is being made as extensive use of as possible, by mixing with foundry kind. Scarcity of trucks continues to hamper home deliveries very considerably. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 95*s.*, and No. 1 is 99*s.*; and for export, No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—There is a good deal of business passing in hematite up to the end of the control period, but buyers and sellers alike appear disinclined to make contracts beyond April 30, when a revision of prices takes place. Supply continues more than sufficient for home requirements, and sanction is given for shipment abroad of some of the surplus iron, but such licenses are still granted only sparingly, and seem, so far, to have been confined to deliveries to Belgium. Nos. 1, 2 and 3 East Coast brands are 122*s.* 6*d.* for home use, and 172*s.* 6*d.* for export.

Manufactured Iron and Steel.—Finished iron and steel manufacturers are well placed. Several works are making the transition to the 8-hours day for those workers who have not hitherto had that privilege. Outlook as regards fuel and labour causes some anxiety, but at present works are very busily employed, and there are heavy inquiries in the market on both home and foreign account. One or two advances in the home prices of steel have been made. The following are among the principal market quotations to home customers:—Common iron bars, 16*l.* 5*s.*; steel ship, bridge and tank plates, 14*l.*; steel angles, 13*l.* 12*s.* 6*d.*; steel boiler plates, 15*l.*; steel joists, 13*l.* 12*s.* 6*d.*; steel rails, 13*l.* 10*s.*; and billets and blooms, 12*l.* 5*s.* to 12*l.* 15*s.*; whilst export prices include: Common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; steel joists, 16*l.* 2*s.* 6*d.*; steel rails, 15*l.* 10*s.*; and billets and blooms, 13*l.* 10*s.* to 15*l.*

Shipments of Iron and Steel.—A serious decrease in shipments of iron and steel from the port of Middlesbrough, at a time when financial equilibrium is hoped to be restored by expansion of foreign trade, is very discouraging. Last month's clearances of pig-iron, manufactured iron and steel, totalled only 20,474 tons, whereas in pre-war days the monthly average was in the neighbourhood of 160,000 tons. In January the loadings were returned at 49,461 tons, and the last monthly despatches recorded during the period of the war amount to 35,754 tons in March last year. January shipments of pig-iron to foreign ports were nearly three times as large as those of last month, the respective figures being 30,011 tons and 10,555 tons. Exports of pig-iron to Italy fell from 10,144 tons in January to 1,286 tons in February; whilst last month France took 8,316 tons, as compared with 13,717 tons in January. Manufactured iron and steel exported last month totalled only 5,695 tons, as against 16,315 tons in January, but despatches coastwise amounted to 2,859 tons last month, as against 1,765 tons in January.

Coke.—Coke continues scarce, and local consumers are pressing for larger supplies. Medium blast-furnace kind is 33*s.* at the ovens, and low phosphorus quality 35*s.* 6*d.* at the ovens.

SMALL TOOLS.—In reference to the Small Tools Order, 1918, dated May 10, 1918, the Minister of Munitions has ordered as follows: (1) The operation of the said Order is suspended since February 28, until further notice. (2) Such suspension shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such suspension or any proceedings or remedy in respect of any such penalty or punishment. (3) The new Order may be cited as the Small Tools (Suspension) Order, 1919.

SPAIN: NATIONAL ENGINEERING CONGRESS.—We are informed that a National Engineering Congress is to be held in Madrid next spring. The various sections are to deal with Public Works and Transports; Naval Transport and Constructions; Mechanics, Engines and Machine Tools; Mines and Metallurgy; Industrial Physics and Chemistry; Electrotechnics; Agricultural Industry; Industrial Forestry; Application of National Industry to War; Elementary and Higher Technical Education; Work Organisation, Hygiene and Social Institutions; Industrial Economy and Legislation. The Congress offices are at Marqués de Valdeiglesias 1, Madrid.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Local Coal Market Position.—During the past week new business on the Cardiff coal market has been rendered very difficult on account of the authorities refusing to grant licences, except in isolated cases, for the shipment of coals to neutral countries, and by an instruction that inland demands were to be given priority. These new instructions are the outcome of the uncertainty of the labour position, and in addition the authorities are taking huge quantities of all the better class steam coals for the purpose of stocking the coaling depots abroad. It is stated that at the end of the present month the "zone" scheme is likely to be abandoned. But this is not expected to interfere with the arrangement of business. Shipments to allied ports are being maintained, but even for these destinations a careful scrutiny of licences is being made. Tonnage at the Cardiff, Penarth and Barry docks is ample, and there are many boats held up in the roads waiting to come into dock. Congestion at the docks is as bad as ever, and although the various authorities are making attempts to speed up the loading facilities of the ports, it will be some time before things can be brought to the normal. A shortage of empty trucks is also aggravating the difficulties of exporters, and some collieries, though they have full order books, have been forced to resort to temporary stoppages on account of a scarcity of wagons. In other cases coals have been standing on the docks awaiting shipment which is delayed by the insufficiency of loading facilities. All Cardiff large steam coals are very difficult to secure, and the same applies to best steam smalls, but the cheaper descriptions of steam and dry smalls remain plentiful, despite an order to the effect that a percentage of these sorts are to be shipped in all cargoes.

Position of Newport Coals.—Transport difficulties continue to retard new business. Colliery owners and exporters are, however, busily employed in the despatch of business already fixed up. The demand for Monmouthshire large and small steam coals remains good, and buyers find it extremely hard to get coals released owing to the heavy demand from the authorities and inland consumers. Neutral business is practically at a standstill, as licences are being granted very sparingly in view of the threatened strike of the miners.

Irregular Strikes.—There is again a crop of stoppages in various parts of the coalfield, without the usual notice. These have been reported to the Joint Standing Disputes Committee of the Welsh Coal Board. The owners are, of course, entitled to take proceedings against the men concerned, but at the request of the men's leaders have agreed to postpone taking action until the latter have had an opportunity of considering the matter and bringing forward any suggestions which they may desire to make after making the necessary investigations. In some cases which have been dealt with, proceedings have been withdrawn on the men giving an undertaking that they will not resort to further sudden stoppage within a prescribed period—three or six months in certain cases. This is an experiment, and if it proves effective it will probably be more generally adopted. The most serious strike for the moment in the South Wales coalfield is that at Messrs. Guest, Keen and Nettlefold's Dowlais Collieries. Here a very aggressive attitude has been taken up, and both parties seem prepared for a longer stoppage than usual. This is indicated by the fact that the company have taken the precaution to take up the horses—a procedure which is hardly ever adopted where the stoppage is expected to be of short duration. In this district there has been appointed a new miners' agent of a more "advanced" type than the late leader of the men, and this may partly account for the trouble.

Compliment to Welsh Coalowners' Secretary. The Mining Association of Great Britain have entrusted to Mr. Finlay A. Gibson, secretary of the Monmouthshire and South Wales Coalowners' Association, the onerous task of working up the whole of the case for the coalowners of the kingdom for the purpose of submitting evidence before Mr. Justice Sankey's Coal Commission. Since his appointment (in succession to Mr. W. Gascoyne Dalziel), Mr. Gibson has established a most complete statistical department in connection with the coal trade, and it was doubtless a recognition of this fact, and of the undoubted organising abilities of the Welsh coalowners' secretary, that he has been paid the compliment of being selected to undertake so important a duty. In addition to his own staff, Mr. Gibson has engaged a number of temporary clerks to assist him to deal with the huge amount of clerical work involved.

Coal Trimmers and Tippers' Demands.—The coal trimmers and tippers of South Wales have just put forward a claim for extra pay and shorter hours through the National Transport Workers' Union, and the National Union of Railwaymen. The trimmers ask for a 46-hours' working week, composed of two shifts—8 hours a day—and a 6 hours' shift on Saturdays. They also claim a 20 per cent. increase on their present earnings, and intimate that these new demands are not to affect a claim for a new trimming tariff now in process of formulation. The tippers also claim a 46-hours' week on the same lines as the trimmers, besides payment of rate and a half for work between 5 p.m. and 10 p.m.; a minimum wage of 8*l.* 5*s.* per week, an annual 14 days' holiday with pay, also, for payment for waiting time at the rate of 1*s.* 6*d.* per man per hour or part-hour. In addition, they request a coal-mixing charge of 3*d.* per wagon and an increase on all other tariffs of 15 per cent. on pre-war rates. A local strike committee has also been formed to link up with other committees in the Bristol Channel.

Shipwrights' Wages Increased.—The Cardiff, Newport, Barry and Penarth district shipwrights, under an award of the Court of Arbitration, have been granted an advance of 5*s.* per week in their wages for men over 18. Those under 18 receive 2*s.* 6*d.* and a further 2*s.* 6*d.* per week on attaining the age of 18. Piece-workers, premium bonus workers and other men working on systems of payment by results, are also granted an increase of 5*s.* and 2*s.* 6*d.* respectively, and the award takes effect from December 7, 1918.

TRADE WITH FRANCE.—The Federation of British Industries, which represents 20,000 firms with a total capital approaching 5,000,000,000*l.*, has been in communication with Mr. Clementel and with Lord Derby, and arrangements have been made for the Federation to send a delegation to France to confer, under the auspices of Mr. Clementel and the British Ambassador, with the important industrial interests of France. The delegation arrived in Paris last Wednesday, and will spend about ten days there. It will be received by Mr. Clementel and the British Ambassador, by the Congrès du Génie Civil and the Fédération des Sociétés Industrielles et Commerciales Françaises, and will be put in touch with various other French industrial organisations. The object of the delegation is to discuss the methods by which British industry can co-operate in the industrial reconstruction of France, and the various problems connected with post-war trade between the two countries. The fact that this delegation is visiting France is a testimony to the desire felt by both sides for the closest commercial relations, and to the wish of French industry to co-operate loyally with the industry of their ally. The headquarters of the delegation are at the Hotel Continental, Paris.

POST-WAR DEVELOPMENTS RELATING TO PUBLIC HEALTH.—On Thursday, Friday and Saturday, March 13, 14 and 15, 1919, a conference will be held at the Sanitary Institute, 90, Buckingham Palace-road, S.W. 1. The conference will be opened on Thursday, March 13, at 10.30 a.m. to 1 p.m., by the Most Hon. the Marquess of Salisbury, K.G., G.C.V.O., and the chair will be taken by the Right Hon. the Lord Mayor of Birmingham (Sir David Brooks, G.B.E.). A discussion on "City Hygiene in Relation to Employment" will be opened by Mr. W. J. Howarth, C.B.E., M.D., D.P.H. (Medical Officer of Health, City of London), followed by Miss Jane Walker, M.D. At 2.30 p.m. there will be a discussion on "Housing for City Clerks and Similar Workers," to be opened by Sir Henry Tanner, C.B., I.S.O., F.R.I.B.A., followed by Mr. Edwin T. Hall, F.R.I.B.A., Mr. J. M. Newnham, Town Clerk of Croydon, and Mr. J. Turner, secretary, National Union of Clerks. On Friday, March 14, at 10.30 a.m., there will be a discussion on "Public Health Aspect of Tuberculosis," to be opened by Mr. N. D. Bardswell, M.V.O., M.D., F.R.C.P. (Medical Adviser, London Insurance Committee), followed by Mrs. Handel Booth and Mr. H. Cardale, M.B. At 2.30 p.m., a discussion on "Public Health Propaganda and Social Work," to be opened by Professor H. R. Kenwood, C.M.G., M.B., D.P.H., F.R.S.E. (President, Society of Medical Officers of Health), followed by Professor E. J. Urwick, M.A., School of Economics. On Saturday, March 15, at 10.30 a.m., a discussion on "Welfare Work in Factories," to be opened by Mr. Edgar L. Collis, B.A., M.B., F.R.C.S. (Director, Welfare and Health, Ministry of Munitions), and Miss Voysey, B.A. (Secretary, Central Association of Welfare Workers); and at 2.30 p.m., a discussion on "Child Welfare Work," to be opened by Mrs. Flora Shepherd, M.B., Ch.B., followed by Mr. Thomas Evans, M.D., D.P.H.

THE MACHINE TOOL AND ENGINEERING ASSOCIATION, LIMITED.—The eighth annual meeting of this association was held on the 5th inst., the chairman, Sir Alfred Herbert, K.B.E., presided. As the report had already been circulated to the members it was not read; it is an interesting one, and fully deals with the activities of the association, and indicates the proposals for extending its influence in the near future. From the discussion and the general tone of the meeting there is no doubt but that the association intends to continue its progressive policy, and there is no reason why, now that the war is over and the period of reconstruction at hand, the machine tool manufacturers of this country should not again take a foremost position in the development of new machinery and plant for the economical production of appliances from our engineering workshops. The war has retarded new designs for general trade, but it has drawn the attention of all to the great advantages to be gained from bulk production, the necessity for standardising designs and the advantages to be derived from the greater use of limit gauges and similar labour-saving appliances. The chairman congratulated the members of the association upon the assistance they had rendered by the special efforts made to supply the large number of general and special machine tools required for the production of war stores and in organising their own workshops for producing shells, fuses and other classes of store so urgently required. The date on which the next exhibition, promoted by the association, should be held, was discussed at the meeting, the opinion being that it was not advisable to hold it until next year on account of the many difficulties to be overcome; the decision is to be regretted as such an exhibition, if held within the next few months should stimulate trade and would certainly indicate that the manufacturers of machine tools were able to cope with reconstruction and prepared for the competition which will, for some time to come, be keen. The proposals for the reorganisation of the association were approved and the retiring directors were re-elected.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 7, at 7.30 p.m., at 39, Victoria-street, Westminster, S.W. Paper by Mr. M. H. Jones (Member), "Warming Buildings by Hot Water."

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, March 8, the seventh lecture of the Session 1918-19, by Mr. H. Pemberton, of Derby, will be given in the Assembly Room of the Cycling Club. Subject: "Some Notes on Jolt Ram Moulding." Chair to be taken at 6.30 p.m. by Mr. Walter Slingsby, M.I.M.E. Discussion to follow.

THE CERAMIC SOCIETY.—Monday, March 10, at 7 p.m., in the Central Schools of Science and Technology, Stoke-on-Trent, when a paper will be read by Mr. D. Roberts entitled "Nigerian Pottery."

THE ROYAL SOCIETY OF ARTS.—Monday, March 10, at 4.30 p.m., Cantor Lecture: "Coal and Its Conservation," by Mr. William Arthur Bone, D.Sc., Ph.d., F.R.S., Professor of Chemical Technology (Fuel and Refractory Materials), Imperial College of Science and Technology. (Lecture I.) Wednesday, March 12, at 4.30 p.m., Ordinary Meeting: "Electric Welding and its Application," by Mr. Walter Leonard Lorkin, A.M.I.E.E. Sir Robert Abbott Hadfield, Bart., D.Sc., D.Met., F.R.S., will preside. Thursday, March 13, at 4.30 p.m., Indian Section: "The Report of the Indian Industrial Commission," by Mr. D. T. Chadwick, I.C.S., Indian Trade Commissioner. The Right Hon. Lord Incheape, G.C.M.G., K.C.S.I., K.C.I.E., will preside.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, March 10, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W. A paper entitled "Experiments with Clay in its Relation to Piles," will be read by Mr. Alfred S. E. Ackermann, B.Sc.(Eng.), A.C.G.I., M.Cons.E., A.M.I.C.E., M.R.S.I.

THE INSTITUTION OF ELECTRICAL ENGINEERS (SCOTTISH CENTRE).—Tuesday, March 11, at 7 p.m., at the Prince's-street Station Hotel, Edinburgh, Brevet-Lieutenant-Colonel W. A. J. O'Meara, C.M.G., will read his paper on "The Functions of the Engineer: His Education and Training."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 11, at 5.30 p.m. Papers to be submitted for discussion: "Electric Welding Developments in Great Britain and the United States of America," by Mr. James Caldwell and Mr. Henry Bailey Sayers; "Experiments on the Application of Electric Welding to Large Structures," by Mr. Westcott Stile Abell, M.Eng., M.Inst.C.E.; "The Application of Electric Welding in Ship Construction and Repairs," by Mr. John Reney Smith. And ballot for new members.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS. Tuesday, March 11, at 6.15 p.m., a paper on "Machine Tools" will be read by Sir Alfred Herbert, K.B.E.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, March 12, at 7.30 p.m., at St. Bride's Institute, Fleet-street, a paper will be read by Captain L. Aitchison (late of Sheffield University), R.A.F., D.Met., B.Sc.(Lond.), on "Recent Developments in Engine Steels," illustrated by lantern slides.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 13, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Lecture on "Dielectrics in Electric Fields," by Mr. G. L. Addenbrooke, Member.

THE OPTICAL SOCIETY.—Thursday, March 13, at 7 p.m., at the Imperial College of Science, South Kensington, S.W. 7, Major Charles W. Gamble, R.A.F., will read a paper "On Some Photographic Apparatus used in Aerial Photography."

THE BIRMINGHAM METALLURGICAL SOCIETY AND THE INSTITUTE OF METALS (BIRMINGHAM SECTION).—Thursday, March 13, at 7 p.m., Joint Meeting at the Birmingham Chamber of Commerce, New-street. Paper by Mr. A. E. Tucker, F.I.C., and Mr. P. A. Tucker, "The Present and Future of the Extrusion of Metals."

THE ROYAL SANITARY INSTITUTE.—Thursday, Friday and Saturday, March 13, 14 and 15, at the Institute, 90, Buckingham Palace-road, London, S.W. Conference on "Post-War Developments Relating to Public Health."

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, March 14, at 5.30 p.m., a discourse will be delivered by Professor A. Keith, M.D., LL.D., F.R.S., F.R.C.S., Fullerian Professor of Physiology, Royal Institution. The subject will be "The Organ of Hearing from a New Point of View." Afternoon Lectures, at 3 p.m.: Tuesday, March 11, Professor H. Maxwell Lefroy, M.A., F.E.S., F.Z.S., on "Insect Problems" (Lecture IV); Thursday, March 13, Mr. Charles Aitken, on "Whistler and Sargeant" (Lecture II); Saturday, March 15, Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "Spectrum Analysis and its Application to Atomic Structure" (Lecture II).

CANAL CONTROL COMMITTEE.—Sir Maurice Fitzmaurice, C.M.G., has retired from the post of chairman of the Canal Control Committee, and the President of the Board of Trade has appointed Mr. Sydney Preston, C.I.E., to succeed him.

PERSONAL.—Messrs. William McLean, Limited, Stirling Chambers, Sheffield, have been appointed selling agents in the Sheffield district by Messrs. George G. Blackwell, Sons and Co., Limited, and the British Thermit Company, Limited, both of Liverpool, for their high-grade alloys.

TEMPLETS, JIGS AND FIXTURES.

(*For Description, see Page* 298.)

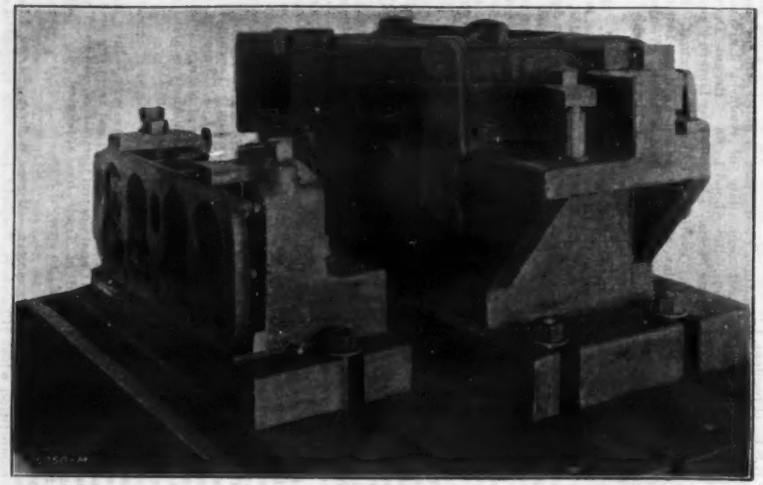


FIG. 621.

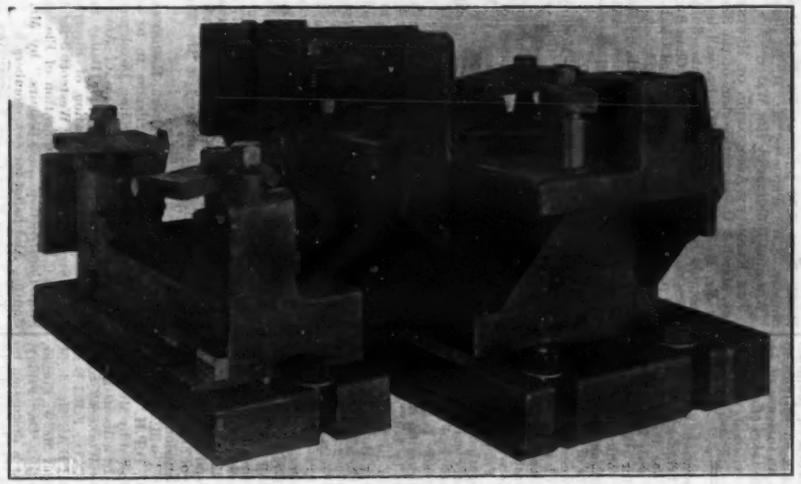


FIG. 622.

FIGS. 621 AND 622. FIXTURE FOR HOLDING PARTS OF INTERNAL-COMBUSTION ENGINES.

FIG. 623. FIXTURE FOR USE IN MILLING TRANSMISSION CASES.

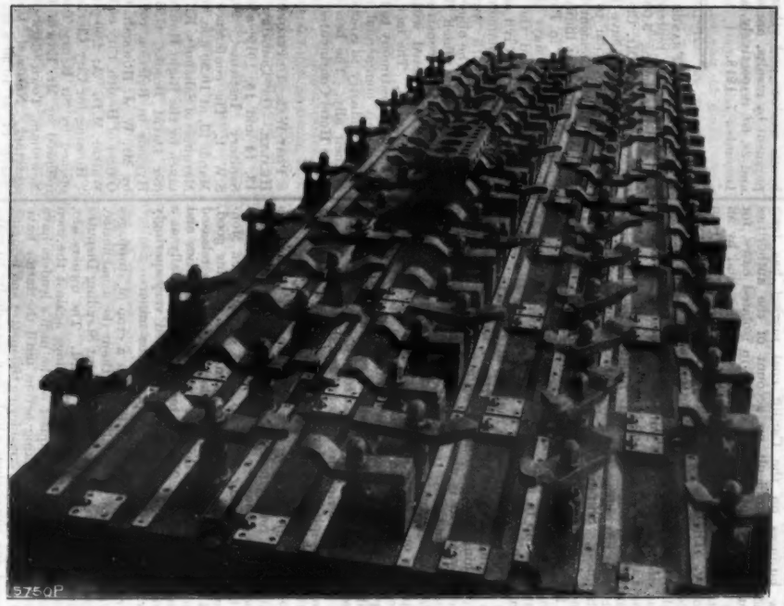


FIG. 624. FIXTURE FOR USE IN MILLING GROUPS OF CYLINDERS OF INTERNAL COMBUSTION ENGINES.

FIXTURES FOR USE IN MACHINING PARTS OF I

(*For Description, see Page* 298.)

Fig. 608.

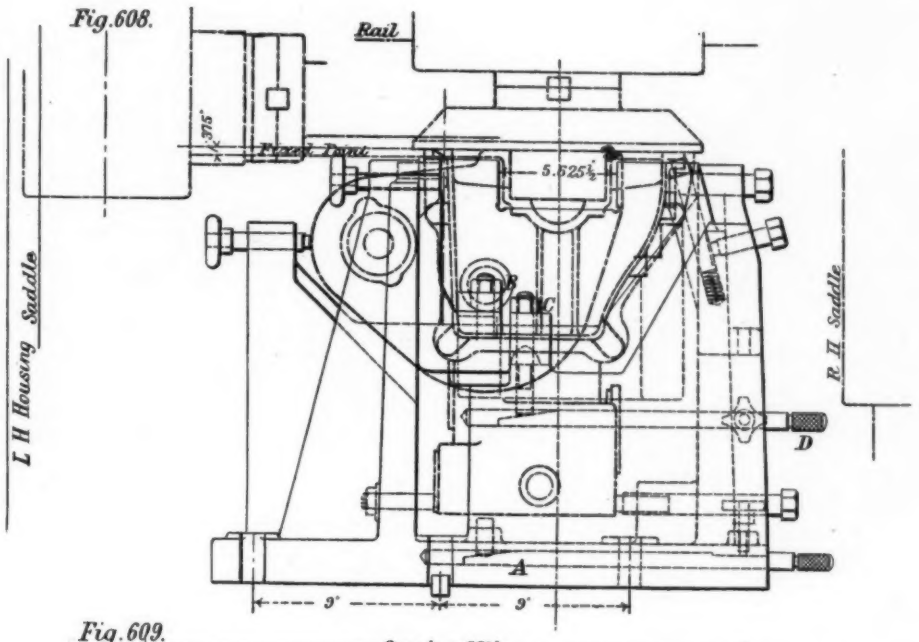


Fig. 609.

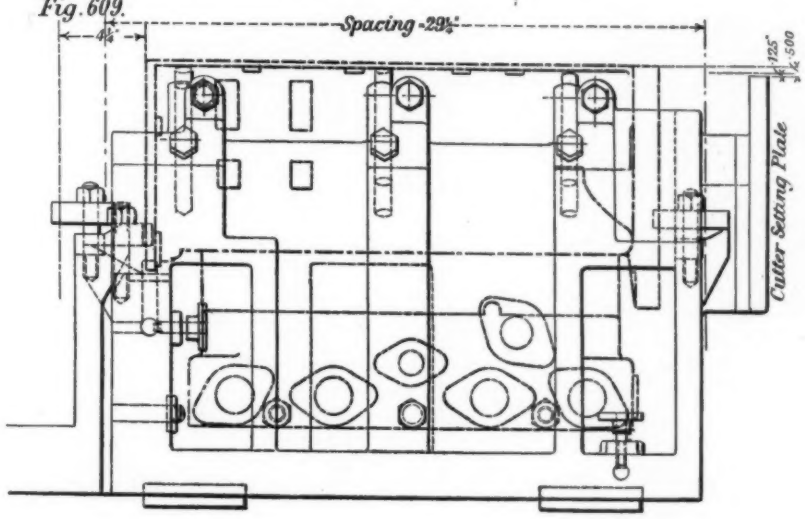
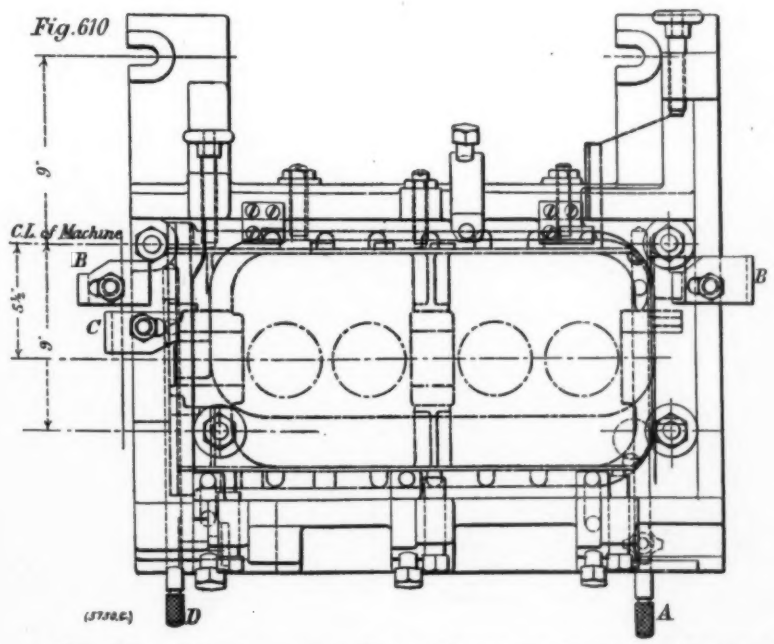


Fig. 610



FIGS. 608 TO 610. FIXTURE FOR USE IN MILLING THE FLANGE AND BEARING-SLOTS OF CYLINDER CASTINGS.

Fig. 613.

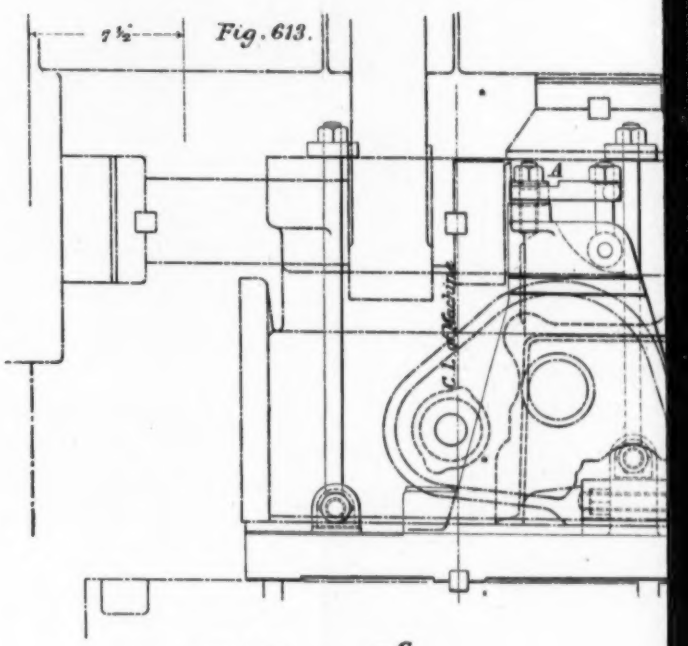
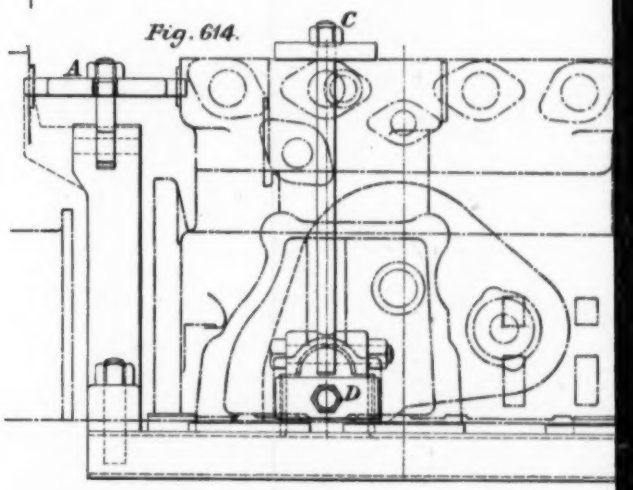


Fig. 614.



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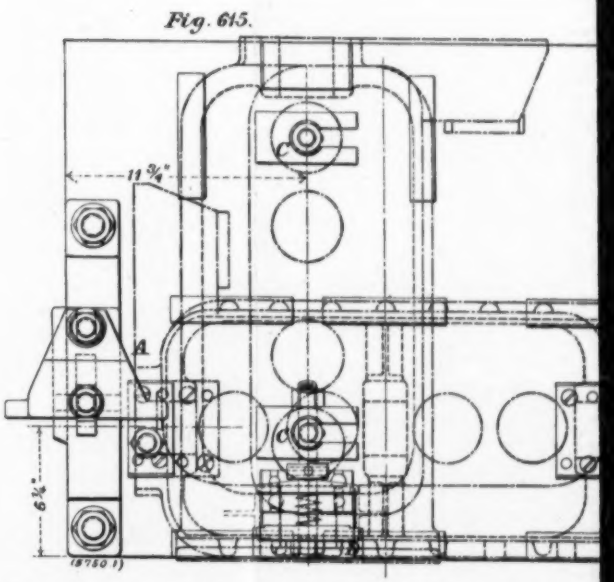
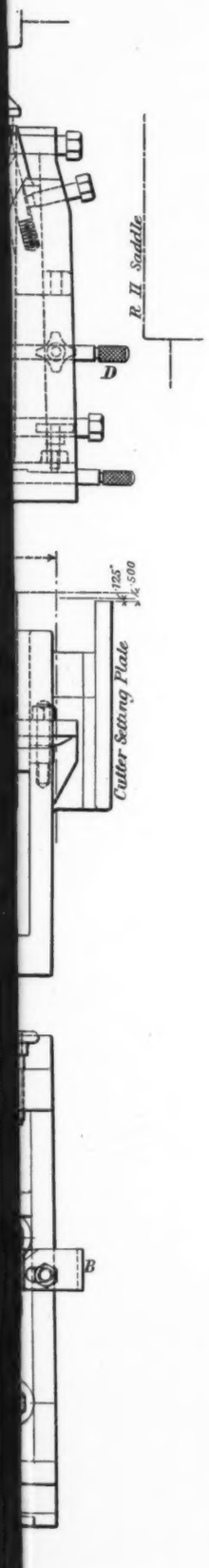


FIGS. 613 TO 615. FIXTURE FOR PERFORMING THE SECOND AND T CYLINDER CASTINGS.

URES FOR USE IN MACHINING PARTS OF

(*For Description, see Page* 298.)



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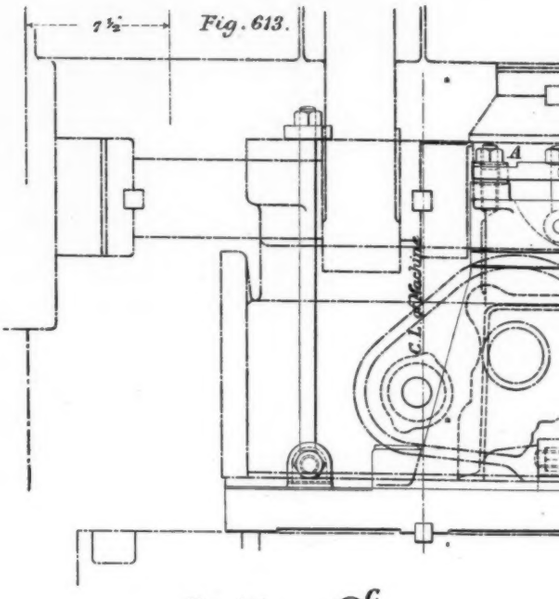

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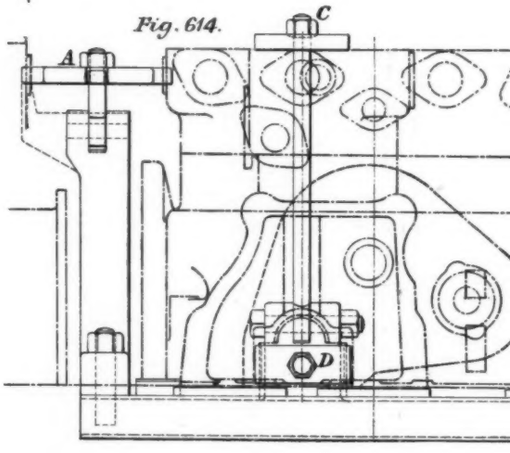

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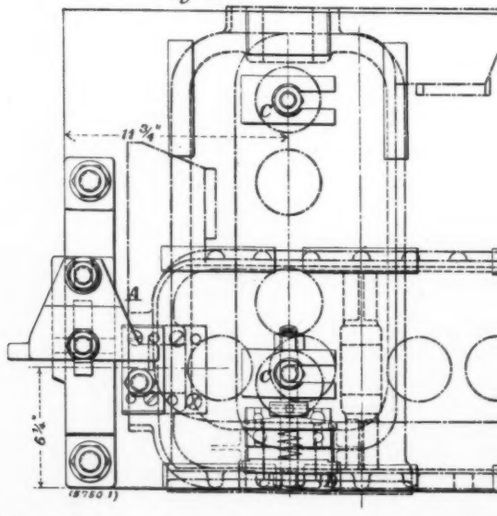

Bearing-Slots

FIGS. 613 TO 615. FIXTURE FOR PERFORMING THE SECOND
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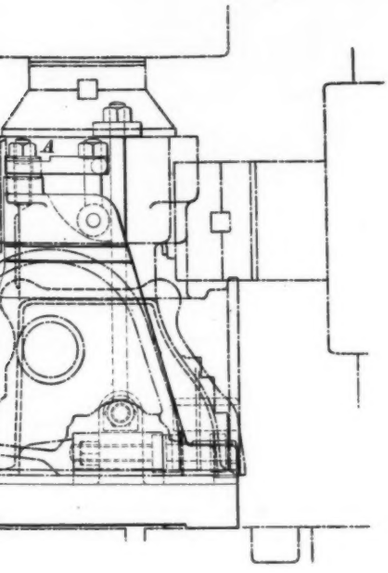
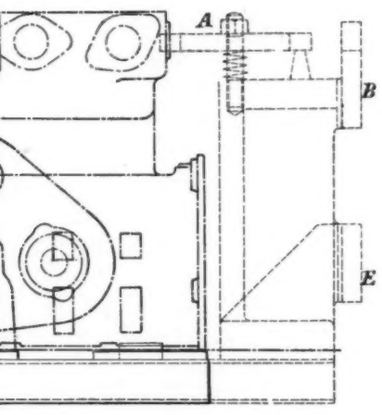
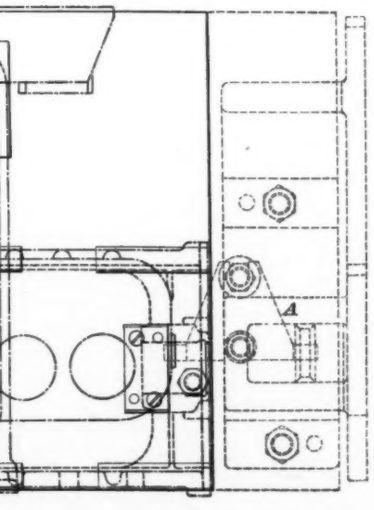
S OF INTERNAL-COMBUSTION ENGINES.

(See Page 298.)

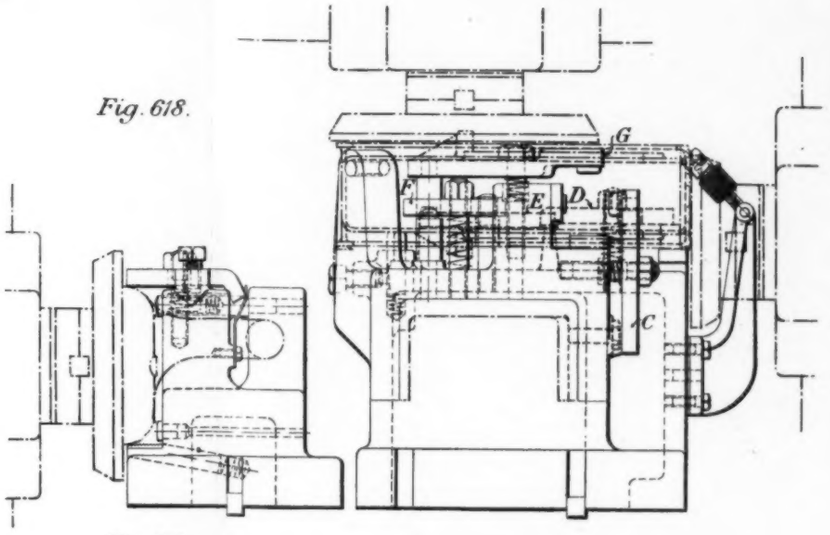






THE SECOND AND THIRD OPERATIONS ON
STINGS.

Fig. 618.



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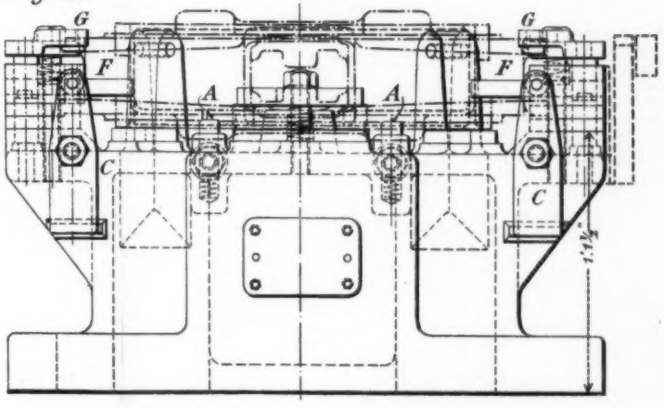

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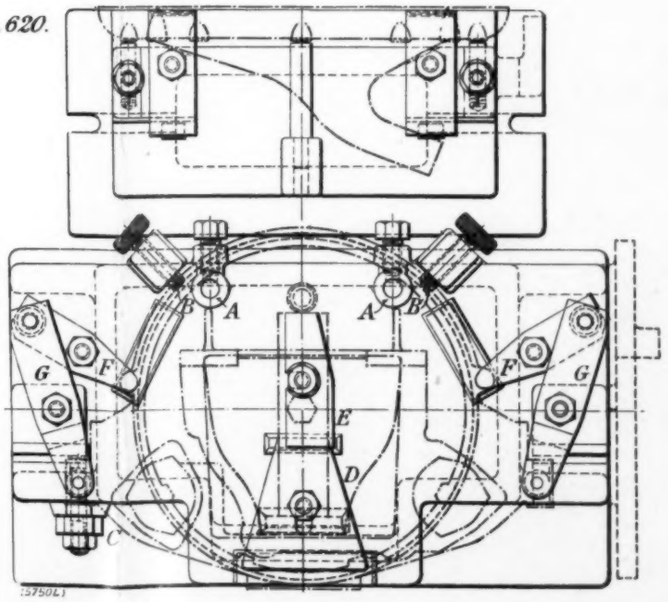

FIGS. 618 TO 620. FIXTURE FOR HOLDING PARTS OF INTERNAL-COMBUSTION ENGINES.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 6
For Canada—	
Thin paper copies	£2 5 0
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Thin paper copies	£2 9 6
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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—8863 and 8866 GERRARD.

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NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 311.

ENGINEERING.

FRIDAY, MARCH 7, 1919.

THE MINISTRY OF WAYS AND COMMUNICATIONS.

THE Bill to establish a Ministry of Ways and Communications and for purposes connected therewith, has been introduced into the House of Commons by Mr. Shortt, the Home Secretary. That it would be ambitious was probably expected by most persons who have watched the course of events since the Government took possession of the railways in August, 1914, to meet the "emergency" created by the war. That it should be so ambitious as it is has doubtless surprised the great majority. The Bill proposes to centralise in a single Government Department all powers and duties of any Government Department in relation to railways, light railways, tramways, canals, waterways and inland navigations; roads, bridges and ferries, and vehicles and traffic thereon; harbours, docks and piers; and the supply of electricity.

The mere transfer to another Government Department—regrettable as the recent multiplication of Ministries is—of powers already vested in the Board of Trade, &c., may be justifiable from the point of view of organisation, but that is the least important feature of the Bill. The crux of the scheme, upon which the business community must focus their attention, is the very material extension of present powers which it is proposed to give the Minister of Ways and Communications—which prospective office has been allocated to Sir Eric Geddes. "With a view to affording time for the consideration and formulation of the policy to be pursued as to the future position of undertakings" to which the Bill relates, a limit of two years is to apply—but during or at the expiration of that period the undertakings may be completely nationalised by the rather innocent procedure of an Order in Council. True, such an Order would have to be laid before each House of Parliament for a period of not less than thirty days during which that House is sitting, and if objected to "no further proceedings shall be taken thereon," but we believe we voice the opinion of the business community in expressing a decided preference for an Act of Parliament before the country is committed to any large scheme of nationalisation.

Moreover, the temporary powers require to be carefully scrutinised, lest they prove to be so wide—or are capable of wider interpretation—that, in practice, control differs from nationalisation in name only.

The Bill transfers to the Minister of Ways and Communications the powers of control now exercised by the Board of Trade over railways of which possession has been taken under the Regulation of the Forces Act, 1871, without renewal of the warrant provided for by that Act, and upon the same terms as to payment as are in force, viz., the State guarantee of the 1913 net receipts of the railways. In addition, the Minister may take possession of the whole or any part of any other railway undertaking, tramway, canal, inland navigation, harbour, dock or pier undertaking, and of the railway wagons of any private owner and of any barges, tugs and other craft required for use on any canal of which possession has been taken. What Parliament will require to know is the intentions of the Government. Mr. Winston Churchill has said that their policy is railway nationalisation: but is it also intended to extend the policy of State ownership to harbours, tramways, &c.? If not, what is the case for conferring on the new Minister powers to take possession during the two years allocated for the "formulation of the policy to be pursued"? As we read the section it would be possible under it for the new Minister to take possession of the port of London as well as of all harbours and docks controlled by independent authorities. What is the case for so drastic an innovation *before* a policy has been formulated? The directors, officers and servants of any undertaking that has been taken possession of by the Minister are to obey his directions:—

1. As to the rates, fares, tolls, dues and charges to be charged.

2. As to the salaries, wages and remuneration and conditions of employment of persons employed on or in connection with the undertaking.

3. As to the working or discontinuance of the working of the undertaking or any part of it, including the keeping open or closing of any stations.

4. For securing that the permanent way, rolling stock, plant, appliances or equipment are satisfactory in type and design.

5. As to the carrying out of alterations, improvements, and additions which the Minister considers necessary for the public safety or for more efficient and economic working.

6. For securing co-operation between undertakings and for securing the common user of facilities, rolling stock and equipment.

7. For affording running powers over their system, or any part of it, to the owners of any other undertaking.

8. For securing that manufacturing and repairing facilities, and auxiliary and ancillary services, shall be used, and the purchase and distribution of stores shall be conducted in such manner as may be most conducive to economy and efficiency.

9. As to the preparation and submission to the Minister at such times and in such form and manner as the Minister may require of statistics and other returns, and of accounts at such times and in such form and manner as he, with the consent of the Treasury, may prescribe.

We have set out this series of powers in detail. They are extremely far reaching. If exercised—and Sir Eric Geddes is not the man to leave power unused—the first result will be to reduce railway boards of directors to the position of cyphers so far as the control of the shareholders' property is concerned: the Minister of Ways and Communications would be in the position of managing director of the railways, harbours, &c. A company's line might be closed wholly or in part; its engines and rolling stock, and even fixed appliances and equipment might be inextricably mixed up with those of other lines; its organisation might be upset; in short, the value of the undertaking might be seriously affected. All this on a guarantee for two years of the same terms *as to payment* as during the past four years, while at any time the Minister might decide to force a purchase of the whole *or any part* of the undertaking, in the manner to which we shall refer later.

We quite agree that it is necessary promptly to dealt with the question of railway rates and charges which need to be overhauled not only with the object of raising revenue to meet the enormous increase in the cost of working the lines, due to concessions granted by the Government to the employees, but to remove anomalies and to improve the system of charging. Power might also be given to facilitate and co-ordinate inter-railway working, and to authorise and finance works for the more efficient and economic working of the railways, but so long as there is the possibility of a complete return to private ownership there should be some respect for the property and corporate existence of the systems which have been built up on the basis of Acts of Parliament. From this point of view we regard the provisions of the Bill as excessive. In this we are supported by the Federation of British Industries, the Association of Chambers of Commerce, the Mansion House Association on Railway and Canal Traffic, the London Chamber of Commerce, &c. These bodies have placed on record their opinion that in any form of control which it may be decided to adopt, the Government should not in any case be concerned with the detailed

administration of the railways. The Bill certainly provides for very considerable interference in administrative matters, and should it emerge as an Act in anything like its present form there will be an enormous extension of the Civil Service. The Ministry of Munitions—with whose organisation Sir Eric Geddes was associated—expanded to enormous dimensions largely on borrowed staff, and it is significant that the Bill with which we are now dealing contemplates the transfer to the Minister of any officer or servant of an undertaking of which possession is taken whose services the Minister may require, "either permanently, with the consent of the officer or servant, or temporarily, with the consent of the undertakers." Moreover, the Bill is far from specific as to the payment of staff transferred to the Ministry. During the war hundreds—if not thousands—of men have worked in various Departments of the State but have been paid by railway and other companies. What may have been justifiable in war time should not be tolerated in future.

We now come to the question of State purchase. As has been pointed out, there is the astonishing proposal that so important a matter shall be done by an Order in Council. We cannot think that this will be sanctioned by Parliament, but it is seriously proposed. The Bill provides that the Minister may purchase by agreement or compulsorily and work the whole *or any part* of any railway, light railway, tramway, canal, waterway or inland navigation, harbour or dock. The only limitation is that a tramway belonging to a local authority or which may be purchased by a local authority, shall only be acquired with the consent of the authority. Railway companies will doubtless have noticed that the basis of any purchase is not defined: the Minister is to have the right to specify the financial arrangement, the only appeal being to a court of arbitration "constituted in accordance with the provisions of the Order authorising the acquisition." Railway directors and shareholders may well contemplate this scheme with misgivings. But in addition to purchasing railway and other undertakings, the Minister may establish new ones, for which purpose he may compulsorily acquire land; he may lease the whole or any part of an undertaking which he acquires or establishes; he may purchase, hire or lease railway wagons belonging to private owners; and may establish, maintain and work transport services by land or water—all by Order in Council. Over undertakings acquired or established the Minister would have absolute control. "He shall be entitled to fix such rates, fares, tolls, dues and other charges as he thinks fit, notwithstanding any statutory provision limiting the amount of such charges or increase therein affecting the undertaking, and shall have all such other powers of management as may be necessary for the purpose," and he may "discontinue the working of any part of the undertaking where he considers such discontinuance is expedient in the national interest." When it is remembered that railway companies own large engineering works, manufacturing anything from furniture to locomotives; operate steamboat services; run hotels, motor cars, and goods and parcels road services; and such diverse branches of industry as laundries, printing establishments, gas works, &c., the potentialities of this project for nationalisation, and State competition with private enterprise, will be apparent.

Thus far the various clauses of the Bill have dealt with railways, tramways, harbours and canals. We now come to roads. In common with the other undertakings named, money may be advanced by the Minister for the construction, improvement or maintenance of roads, bridges and ferries. The Development Commissioners are to be swept aside, and for the purpose of advances in respect of roads the Minister may classify them "as he thinks fit." He may also call upon road or bridge authorities to furnish—in such manner and form as he may direct—accounts, statistics and returns, an obligation which applies to railway, tramway, canal, dock, harbour, pier and electricity undertakings. Apart from transferring to the Ministry of Ways and Communications the powers and duties of other Government departments in regard to roads, bridges and ferries, and vehicles and traffic thereon, and the supply of electricity, the only provisions in the Bill in regard to roads and electricity undertakings are those mentioned above. In our opinion, the association of roads and the supply of electricity with railways is wholly unjustifiable. As regards the former, it would seem to be better to leave them under the Road Commission. That Commission has done most excellent work and has collected a vast amount of data and experience which could be rendered available if the funds were forthcoming. In any case the improvement of roads and the regulation of the traffic on them should not be entrusted to a department whose interest might conceivably express itself in action (or inaction) calculated to throw traffic on the railways.

As regards the supply of electricity, the fact that the Bill contains merely one or two lines on the subject appears to us to be evidence that it is quite outside the scope of the new Ministry. The Institution of Electrical Engineers has been agitating to get the matter put into the hands of a body of Commissioners who would really understand it. The problem bristles with difficulties. It is very easy to suggest putting electric generating stations at the pit-head, but investigation often shows that better positions might be found. Although electricity has no weight or mass, it is a most expensive agent to transmit and it has repeatedly been shown that it is far cheaper to carry coal from the pit to a town than to transmit the electric energy between the two places over wires. It is the most unconvincing special pleading to suggest that the control of electric supply should be vested in the Ministry of Ways and Communications because the railway property might be used for lines of overhead high-tension wires, while as regards railway electrification we are far from sharing the opinion of a labour correspondent of a non-technical journal that "railways will in the near future be electrified and canals will carry electrically-driven barges."

As regards canals, we think there is far too great importance attached to them in the public mind, and that, with two or three notable exceptions, such as occur in Lancashire and Yorkshire, the day of canals is over. We recently called the attention of a leading authority on canals to the oft-repeated statement that railways killed canals. He replied: "Certainly—and who killed the pack-horse?" Canals could not compete with railways, and in a small country such as this, there is no field for them. The fact is that had it not been for the acquisition of canals by railway companies—often against their better judgment—they would now be derelict, as are many of those which remained in the hands of canal companies. We could quote a substantial list of abandoned canals, and a careful perusal of the evidence given before the Royal Commission on Canals and the report of that Commission will convince any but the most biased advocate of waterways that the attempt to resuscitate them will only involve throwing good money after bad.

Apart from the fact that railway companies own a few harbours and docks, that class of property—and piers—seems to have no particular connection with railways. Many of them are owned and governed by Trusts who have managed them for many years in a most satisfactory manner, and there does not appear to be any good reason for taking them out of their hands. These Trusts include a number of local traders who know exactly the needs of the districts, and are much more capable of providing for them than a State Department would be.

There remains for consideration what should be done with the railway undertakings. Our readers will remember that quite recently we have devoted considerable attention to the railway problem. After close investigation, we have shown that under the system of control which has existed during the last four years very great economies in working have been effected; train services have been reduced to about half their pre-war dimensions; the greater part of the railway companies' own rolling-stock is being used in common; goods traffic has been allocated between the different companies in such a way as to ensure that it travels by the most direct route; there has been a large reduction of the staff; stations and receiving offices have been closed; the clearing-house establishment has been practically non-existent; in short, more economies have already been effected than are likely to be maintained in the future. The mere restoration of passenger train services would involve greater expenditure than would be saved by sweeping away boards of directors or the establishments of general managers; in other words, it may safely be claimed that economies in expenditure are at their maximum, yet the estimates now before Parliament show that this year a deficit of £60,000,000 on railway working is anticipated. This is entirely due to the concessions which have been granted by the Government to railway employees, and the end is not yet. Negotiations are taking place with the Trade Unions, and as these are being conducted on behalf of the Government we have little doubt that the Trade Unions will secure the longest end of the stick. As was recently stated by Judge Robert S. Lovett, who has resigned the post of Director of Capital Expenditure for the Railroad Administration of the United States, nobody can claim that a Government can conduct a business in the same way as a private corporation at the same expense; cost in every Department would mount, and the savings would soon vanish.

What has to be secured is that the financial position of the railway companies shall be restored. This can be done by reducing expenditure or increasing the revenue, and it might be facilitated by a well-considered form of Government control. The Board of Trade have always had considerable powers over the railways, and there is no harm in transferring those powers to a new authority, especially if that authority proves to be broader minded and less bound by red tape than the Board of Trade. It is also necessary to invest some Department of the State with the power of varying railway rates and charges and simplifying the present basis of charging. Further, as the railway companies will not be in a position to raise capital, it is necessary that, under certain conditions, the State should finance schemes of improvement, but having said this, we hold strongly to the opinion that the detailed administration of the railways should be vested in the individual companies, and that the State should not embark on a scheme of nationalisation until the whole matter has been thrashed out in a much more complete manner than has, so far, been the case. We have advocated that the Royal Commission on Railways of 1913 should finish its investigation, and in our issue of January 17, reasons for suggesting that course were given. If a Royal Commission is objected to, then the Select Committee which considered the question of transport last year might be re-appointed to enable it to complete the work it commenced. To rush through Parliament a measure which not only confuses control with purchase, but is calculated to extend Governmental bureaucratic methods to the transport industry, is, in our opinion, wholly unjustifiable.

PROHIBITED PATENTS.

UNDER the Defence of the Realm Act certain patent applications relating to war matters were withheld by the Patent Office from publication during the war. These specifications are now about to be published, and this has a very important bearing as regards three classes of people: (*a*) The inventors concerned as to their foreign patents, (*b*) subsequent inventors from the point of view of obtaining British patents, (*c*) the inventors of class (*b*) with respect to the validity of any patents obtained.

Dealing with class (*a*), many countries have a provision in their patent law that valid patents can only be secured if the invention has not been published in any country, thus differing from the British law, which only considers publication in this country. Assuming, therefore, that these inventors are not entitled to the benefits of the International Convention, which happens in quite a large number of cases owing to lapse of time or to the particular country not being a party to the Convention, then publication by the Patent Office of the invention in this country will prevent any foreign patent of the class of countries in question being valid even if it be secured.

A special case has to be made for the United States of America, and one or two other countries, if more than twelve months has elapsed since filing the British application, because a valid patent can be obtained in the States, and can only be so secured in these circumstances, provided that the American patent be granted before the British patent be sealed. Sealing of the British patent will take place almost automatically, provided there be no opposition after acceptance of the specification in this country, so no time should be lost if the application be one of the kind considered here.

As to class (*b*), it makes a very material difference to an inventor whether he is to deal with a specification printed before the date of his application or whether he is only to deal with one lodged but not printed before that date. Two different sections of the Patent Act come into question, and specifications not printed can only affect an applicant by virtue of what is called prior grant, that is to say, they do not disclose any information or add to information at the date of the second application, but can only limit matters in that the Crown cannot grant a valid patent for the same thing twice.

The remarks under class (*c*) are almost identical with those of class (*b*), that is to say, if a case has been withheld from publication by prohibition or otherwise, it can only affect a subsequent inventor (provided he lodges his application before acceptance of the earlier case) if the first patent proceed to a grant and if the grants be substantially similar. Thus, a patent practically for a machine embodying a new principle or some other broad invention, if published before a patent for a slight modification thereof, would very seriously affect the subject-matter of the second patent, but would have very little effect against it if it were not so published, providing that there were a small but distinct difference; for, in the second case, without prior publication, one would be entitled to say that the principle was not old at the date of the invention.

ETHER AND MATTER.

On the same Friday, February 28, on which Sir Oliver J. Lodge, F.R.S., discoursed on the "Ether and Matter" at the Royal Institution, it became known that he had announced his intention of resigning his office as Principal of the University of Birmingham—in July, after nineteen years of work there—to make room for a younger man and to devote himself to the study of the Ether of Space. That has been the chief problem of his work for many years. He experimented on the ether drift in 1891, at Liverpool; the electrical theory of matter has had his strenuous support from its early days; he has written books and articles on Modern Views of Matter and on the Ether of Space; his presidential address to the British Association dealt with the discontinuity of matter and the continuity of the ether, and also with the rapid scientific progress and fundamental scepticism of our age; and his most recent papers concern the astronomical consequences of the electrical theory of matter. The electrical aspect of the inertia problem, and the analogies between the atomic microcosm and the astronomical macrocosm were prominent features of his discourse. We should mention that Principal Lodge had stepped in for Professor J. A. McClelland, who was to have been the lecturer of that evening.

We were all moving, Sir Oliver said, in opening his discourse, through the ether of space at a rate estimated at 19 miles per second, possibly at a much faster rate; for our whole planetary system was drifting through space. But we were ignorant of that motion and of its direction. There was nothing to propel us apparently, nothing to stop us, and therefore we went on. If there were no Earth, we should be moving just the same, though there would be no diurnal rotation. Movement and inertia were fundamental properties of matter; nothing was at rest, unless under the influence of balancing forces. But we had no sense of velocity, only a sense of acceleration—we felt that in a lift—and hence our ignorance of the speed and direction of our movement through space and the ether.

Some said we should always remain ignorant. What we could measure was motion of one piece of matter relatively to another. The principle of relativity questioned the possibility of our ever obtaining any knowledge of absolute velocity with respect to the ether, because all force was supposed to be transmitted by the ether, and because there was always, in our experiments, some compensating effect cancelling out the movement-term looked for. Sir Oliver hoped that we might yet find a way of devising a test experiment. But the principle of relativity was certainly having its day. It had made a definite prediction: a light ray, from a star, grazing the sun, should be deflected by 1¾ seconds of arc. That prediction was soon to be tested at the solar eclipse of May 29, which would be visible in Brazil and the Southern Atlantic. Sir Oliver thought that, if any deflection were observed, it would not amount to more than ¾ second, which would only mean that a wave-front was subject to gravity. He hoped, however, that the observations would fail to establish any deflection and in that case we should be happy to live on as before.

Sir Oliver Lodge then briefly referred to the many attempts made to ascertain whether the Earth drifted through the ether. Experimentally the task that Michelson and Morley had set themselves in their first investigation had been to determine whether the time taken by light to travel with the stream of ether, through which the Earth was supposed to be racing, was the same as that taken to go against or across that stream. They divided a beam of light into two parts, reflected it back on itself, and looked for any displacement in the interference bands of the two rays after turning the horizontal stone slab supporting the whole apparatus on the mercury cushion on which it rested. The displacements observed were so small, that one might say, that nothing happened when the stone was turned. Why not? The answer given in terms of the electric theory of cohesion was, because the turning stone changed its dimensions, being shortened in the direction of its motion by an exceedingly small amount of course. The question which Sir Oliver Lodge himself attempted to answer in his Liverpool experiments—which, he mentioned, he conducted with the financial support of Mr. Hope, a shipbuilder—was whether moving matter carried the ether with it. He clamped two horizontal steel discs together, 1 yard in diameter, so as to leave an air space, 1 in. in thickness, between them; between the discs he mounted four plane mirrors at the ends of two diameters at right angles to one another, in such a way that a beam of light entering on the one side was reflected round three times, half of the beam travelling one way, half the other; thus six rays of alternating directions fell upon the fourth mirror on which interferences were observed. The discs were mounted on the top of the vertical shaft of an electric motor and rotated in one or the other direction at several thousand revolutions per minute. Sir Oliver was advised to fix up boiler-plate screens for his protection. If the ether had been carried round with the discs and the air between the discs, displacements of 10 bands should have been observed; but in spite of the terrific churning of the air, the shifting of the bands was insignificant, and the ether appeared unaffected by the motion. The experiments thus, Sir Oliver considered, seemed to demonstrate the electric theory of cohesion, into which he did not enter.

Electricity itself, he proceeded, possessed an analogue of inertia; Faraday discovered it in his "extra current," Maxwell called it self-induction. Sir Oliver demonstrated in simple ways by fitting his switch with a long lever and his galvanometer with a long pointer. In the ordinary electric circuit the lever and pointer moved in unison; when a strong electromagnet was inserted in the circuit, the galvanometer lagged distinctly behind, and when the galvanometer was replaced by a Morse sounder, the click was perceptibly delayed when the circuit contained self-induction. In these experiments the circuit was made; when in other experiments the circuit was broken, the extra-current caused the interruption spark to be powerful and noisy. The recent researches of Kamerlingh Onnes, Sir Oliver continued, supplied another illustration of electric inertia. At ordinary temperature a current flowing through a metal died away in a very small fraction of a second, unless sustained by an electromotive force; at very low temperature, however, at 4 deg. C. absolute, Kamerlingh Onnes observed that a current, once excited, diminished to half its value in 4 days and was still measurable after 14 days. Until J. J. Thomson had given the mathematical theory of electrical inertia, however, it had been uncertain whether there was real electric inertia or only a semblance of it. It was then proved that if we added an electric discharge to a neutral body, we increased its electric inertia, because a mass of ether proportional to the potential energy was bound by the body. On a hollow brass ball, ¼ lb. in weight, Sir Oliver explained, that increase in mass or inertia would be absurdly small, something like a million-millionth of a grain. But the increase was given by the formula:

$$2\,\frac{\mu\,e^2}{3\,a}\left(1+\frac{v^2}{2\,c^2}\right)$$

where μ was the magnetic etherical constant such that, for $\mu = 1$, e was in electro-magnetic measure;

e the electric charge (positive or negative did not matter, since the term was e^2).

a the radius of the sphere, v its velocity and c the velocity of light.

That formula indicated that the inertia could be increased in two ways, by making the a and the sphere very small, and by giving it a high speed. Speaking of the a first, Sir Oliver asked whether the increase would be worth troubling about, if we made the sphere as small as the atom. To give an idea of the dimensions concerned, the lecturer quoted a simile used by Sir William Crookes: Imagine a globe, less than an inch in diameter, full of air; join it to a pump capable of extracting 1,000,000 atoms per second; how long would it take to empty the globe? The answer was not some days, not a few years, but 500,000 years. Yet the effect of adding a charge to an atom would still be insignificant. But if we passed to electrons, the unit charges of electricity, the charge would account for the whole of the inertia of the electron, and in that case the speed of the body—so far disregarded—became an important factor. That speed, we knew, might be terrific and approach the velocity of light. We could not produce such speeds by machinery; but radium did emit particles at those speeds, and in that way the electric inertia of a charged body had been proved not to be merely an analogue, but real, and in accordance with theory. That was the basis of the electrical theory of matter. On that theory an atom of matter was composed of units of positive and negative electricity. Consideration of the extreme porosity of matter helped us to understand the possibility of such a structure. Matter was not continuous; the atoms themselves consisted of empty spaces dotted with specks of matter, and they were as full of empty space as the solar system. A comet dashing through our solar system was not likely to hit the sun or any planet; nor were the particles shot off by radium likely to collide with anything before they had collided with thousands of atoms.

So far, Sir Oliver continued, he had only given expression to views of almost universal acceptance. What he was going to say was more controversial, though also based on research. The suggestions as to the structure of the atoms had assumed definite shapes. There was a positive nucleus about which electrons circulated in planetary orbits—one electron for hydrogen, two for helium, seven for nitrogen, eight for oxygen, &c. Whether each electron had an orbit of its own, or whether several electrons might share an orbit, was not settled. The electron of hydrogen, *e.g.*, might also be able to describe several orbits. But the atom was regarded as a planetary system, and the number of planetary electrons turning about the nucleus—the positive charge of which balanced the sum total of the negative charges—depended upon the atomic number of Moseley. Those numbers went up to 92 (uranium). There were other analogies between the atomic system and the planetary system, some perhaps fanciful. Sir Oliver put on the blackboard a table arranged in three horizontal rows. In the

upper row were the squares of the natural numbers, 1, 4, 9 . . . ., representing the different orbits possible in Bohr's atom; in the row underneath were the names of the planets Mercury, Earth, Mars, &c.; in the third row figures proportional to the mean distances of the planets from the sun. There was a certain agreement between the figures in the same vertical column; but, Sir Oliver admitted, he had no room for Venus in his table, and there should be a group of asteroids between Jupiter and Saturn of which astronomers knew nothing. Sir Oliver added that he had intended to refer to the disturbances of the electrons which spectrum analysis revealed to us; but he had seen that Sir J. J. Thomson was going to lecture on spectrum analysis and atomic structure. He wished he could hear those lectures, and he would confine himself to a few remarks. If the orbits of the electrons were circular, the electrons would not radiate; if the orbits were elliptical, and hence were accelerated in their speed, radiations (not transversal) would be set up (Sir Joseph Larmor). When ultraviolet light, β rays or X-rays of high frequency, disturbed the electron, its oscillations might get up speed until it flew away—by resonance, Sir Oliver suggested. A pendulum was deflected and caused to oscillate by almost any force. A body in unstable equilibrium—*e.g.*, a brick placed on edge—might be submitted to small shocks, and nothing would happen; if the forces were sufficiently strong or repeated many times, the brick would be upset. In such cases a definite amount of energy was required to produce an effect which might be almost explosive, and in some such sense, Sir Oliver said, he understood the quantum hypothesis.

Concluding, the lecturer remarked that an amazing amount of knowledge had accumulated already before the war, and that extraordinary vistas were opening out. We were recognising once more that the infinitely great was like the infinitely little, and that there was an astronomy of the atom. We knew that the electromagnetic energy was not in the wire carrying the current, but in the ether around the wire. Our expressions for the inertia were no explanation, but only relegated properties to the ether. We attended to physical properties because they appealed to our senses; we should attend to the ether, which did not appeal to our senses. "The wise man keeps his mind open to every avenue of thought."

NOTES.

STATE AID FOR INDUSTRIAL RESEARCH.

WE publish in full, on page 317, a document recently issued by the Department of Scientific and Industrial Research, explaining the scheme under which it is proposed to provide State aid for industrial research. The war, which has so completely disorganised many of our industries, has also amply demonstrated the value of research work. Few people, we imagine, would now dispute the statement that applied science played a very important part in bringing the war to a satisfactory conclusion. Hardly less important is the task now before us of re-establishing our industries and maintaining them at the maximum possible degree of efficiency. Without greatly increased efficiency it will be impossible for us to improve, or even to regain, our pre-war position as a manufacturing nation, since higher labour charges and increased foreign competition will now have to be faced. These conditions can only be met by increased productivity combined with reduced manufacturing costs, so that the vital necessity for research work to improve existing methods and discover new processes is obvious to all. Research work is, however, expensive, so that only large organisations can undertake it on a suitable scale. Moreover, if two or more concerns are working to the same end it is obvious that effort may be wasted by work overlapping. Co-operation is thus desirable, and it has therefore been proposed that Research Associations for each industry, or for each branch of large and complex industries, should be formed, and mainly supported, by the manufacturers concerned; financial assistance will, however, be given by the Government Research Department if this is required. It is unnecessary further to explain the scheme here, but manufacturers should certainly give it very careful consideration, and co-operate at the earliest possible moment in the formation of the suggested Research Associations. Obviously much depends upon the selection of the *personnel*. Men of high scientific attainments combined with practical knowledge of the technical side of the industries concerned are required for the work, and the remuneration must be such as to attract and retain men of this calibre. Fortunately their selection is in the hands of the manufacturers themselves, and, generally, it is satisfactory to note, that the Government does not intend to interfere with the organisation of the associations, even when it grants monetary aid. The State may, however, limit the absolute ownership of results obtained with public funds, and may also veto proposals to give results to foreigners; no reasonable objections can, however, be raised to this feature. Generally the scheme seems capable of producing excellent results, and the most pressing need at the present time is for manufacturers to make the necessary arrangements for setting up the Research Associations. This should be done without unnecessary delay, as research work is usually slow, and the need for results which will enable our industries to increase their production and improve the quality of their products was never more urgent.

CHINESE PORCELAIN.

Though Europe has been manufacturing porcelain for nearly two hundred years, Chinese porcelain remains unequalled in many respects, and it is not astonishing that, in the popular belief, porcelain manufacture is an art in which the Chinese have excelled for thousands of years and which is still being carried out on old traditional lines. As a matter of fact, Chinese pottery, deserving the name of porcelain, is hardly as old as our era, and progress the result of laborious experimenting, can distinctly be traced from the Han dynasty (256 B.C. to 220 A.D.) through the dynasties of Tang (618 to 906), Sung (960 to 1279), Yuan (to 1308), Ming (to 1644), and Ching, the Manchu dynasty which was deposed in 1912. That was pointed out by Professor J. Norman Collie, F.R.S., of University College, in a course of three lectures delivered at the Royal Institution last month. In some sections of early porcelain, which Dr. Collie exhibited, the grain was coarse, there were black spots of undissolved clay and lumps of transparent quartz, whilst in specimens from the best, Sung and Ming periods, the grain was finer, there were few black spots, and some crystals of sillimanite could be distinguished, an aluminium silicate, which does not form below 1,400 deg. C. The early green (lead) glazes used by the Chinese, Dr. Collie had found to be the same as the ancient tile glazes of Babylon (dating back 6,000 years probably), and Egyptian glazes and beads of all the Egyptian dynasties. Those glazes had probably come to China from the West. But the later whitish glazes of the Tang and Sung periods were Chinese inventions. This green lead glaze was a lead glass, coloured by the addition of copper oxide; the glass was pounded up, painted on the pottery, and baked at about 700 deg. C. The feldspathic white glazes had to be fired at 1,400 deg.; they made Chinese porcelains look as if the surface itself had been fused and congealed, and that appearance still distinguished Chinese porcelains. In some of the many beautiful specimens exhibited by Dr. Collie the temperature had not been sufficiently high to effect complete fusion. Decorative patterns were either incised in the pottery or painted on, and the painting might be done before glazing—if the colours stood the high temperatures—or afterwards, on the top of the glazing. A great variety of beautiful colour effects were obtained by adding relatively few metallic oxides to the feldspathic glaze; copper and iron would give green, red or greenish-blue; the blue was always due to cobalt, the yellow to antimony; the rose tint due to gold had probably been introduced from Europe. Showing some glaze fluxes prepared by Sir Herbert Jackson, Dr. Collie demonstrated that colourless fluxes assumed different colours on being reheated in the oxidising or reducing flame; the reproduction of definite tints on the porcelain was a matter of great difficulty. The Chinese were quite aware that certain manganese ores give a purple glass neutralising the pale green (iron) tint of common glass, and by analysing small samples (from precious specimens) Dr. Collie had ascertained that the whitish glaze had, in the Tang period, contained up to 9 per cent. of phosphates, which were not used after 1600 apparently. Though the title of the lectures was: "Chemical Studies of Oriental Porcelain," Dr. Collie confined himself to Chinese porcelain, and his chemistry was general, not sufficiently detailed for the manufacturer. He spoke as the art collector, and he delighted in quoting from the quaint manuscript of Hsiang Yuan-Pien, an enthusiastic artist and collector living about 1450, who left an illustrated description of his porcelain treasures, for one of which he had paid 600*l*. That book was brought to London and accidently destroyed by fire in 1887; copies had fortunately been taken in time. The first European porcelain was made in Meissen by J. F. Böttger about 1709; before that it was believed that the Chinese buried their pottery in order to turn it into porcelain.

INDUSTRIAL NOTES.

THE Ministry of Labour referred, last week, thirty-six labour disputes to arbitration, rather more than half being referred to the Interim Court of Arbitration for Settlement under the Wages (Temporary Regulation) Act, 1918, the remainder being referred to single arbitrators appointed by the Ministry under the Conciliation Act, 1896. Two *ad hoc* Courts of Arbitration have also been formed.

Among the principal claims put forward for arbitration were—an application by operative heating and domestic engineers for a general advance of 15*s.* per week, further references affecting the engineering and shipbuilding trades, including claims for an increase of wages by ship constructors and shipwrights, and a claim on behalf of boilermakers for a 20 per cent. advance in wages. An application is also to be considered for an increase to carpenters and joiners in the Dunfermline and Rosyth area. Two other cases of importance are an application for a general advance in wages to railway shopmen and an arbitration concerning dock labourers in Ireland.

Cases in connection with the following have also been referred:—Explosives workers, drugs and chemicals industry, and various cases affecting employees of local authorities.

In the present week a number of disputes have also been referred to arbitration and the claims are being dealt with under the same Act.

The Minister of Labour announces that, in order to secure a more effective administration of the work in Ireland of the Ministry, its organisation is being extended into an Irish Department. The Irish Department will contain branches corresponding to each Department of the Ministry in London and will be responsible for all such labour matters in Ireland, within the province of the Ministry of Labour, as are capable of being dealt with locally, including matters arising under the National Insurance (Unemployment) Acts, 1911 to 1918, the Conciliation Act, 1896, the Wages (Temporary Regulation) Act, 1918, and the Trade Boards Acts, 1909 and 1918. Mr. Gordon Campbell of the Ministry of Labour has been appointed Secretary of the Irish Department. Communications should be addressed to the Secretary, Ministry of Labour, Irish Department, Lord Edward Street, Dublin.

The existing scheme for Out-of-Work Donation (Civilian Workers) provides a maximum of 13 weeks' donation. It has been decided that, subject to the fulfilment of *certain special conditions*, applicants who have drawn the full 13 weeks may be granted a further policy entitling them to draw an additional amount of donation (not exceeding 13 weeks) on a revised scale, provided that they satisfy the usual conditions for the receipt of donation, such as proof of unemployment, inability to obtain suitable employment, &c., The additional policy may in certain cases be granted provisionally for a shorter period than 13 weeks.

An additional policy will only be issued upon the recommendation of the Local Advisory Committee (or, in the case of persons under 18, the Juvenile Employment Committee) who will require to be satisfied that the applicant complies with each of these special conditions, viz., that the applicant is:—(1) normally in employment; (2) genuinely seeking work; and (3) unable to obtain it.

In cases where an additional Out-of-Work Donation Policy is granted, the rates of donation will be as follows:—Men, 20*s.*; Women, 15*s.*; Boys (between 15 and 18), 10*s.*; Girls (between 15 and 18), 7*s.* 6*d.* a week.

There will be no change in the rates of supplementary donation for dependent children under 15 years of

age, which will remain at 6s. a week for the first child, and 3s. a week for each additional child.

Payment of donation under an additional policy will, in any event, not begin to be payable before the expiration of six week-days after the last day for which donation was paid under the original policy, and the usual waiting period of three days' unemployment (which may be part of this interval) must be served before donation becomes payable.

Applications for an additional policy must be made on Form D.29 obtainable at any Employment Exchange or Branch Employment Office.

The following have been appointed to be the members of the Royal Commission appointed under the Coal Industry Commission Act:—Chairman, the Hon. Mr. Justice Sankey, O.B.E.; Mr. Arthur Balfour, J.P.; Mr. R. W. Cooper; Sir Arthur Duckham, K.C.B.; Mr. J. T. Forgie; Mr. Frank Hodges; Sir Leo Chiozza Money; Sir Thomas Royden, Bart.; Mr. Robert Smillie, J.P.; Mr. Herbert Smith; Mr. R. H. Tawney; Mr. Sidney Webb; Mr. Evan Williams.

The Commission will have the assistance of Sir Richard Redmayne, K.C.B. (Chief Inspector of Mines and Technical Adviser to the Controller of Coal Mines), and Mr. S. J. Chapman, C.B.E. (Ministry of Labour). The Secretary of the Commission is Mr. Arnold D. McNair, C.B.E., of the Coal Mines Department.

A preliminary meeting of the Commission was held on Monday last, at 2, Queen Anne's Gate Buildings, S.W. 1. All the Commissioners were present, with the exception of Mr. Herbert Smith, who was unwell. The sitting was private, and lasted from 3 to 6.45 p.m. The questions under consideration related to methods of procedure and the nature of the evidence to be called for.

Since Tuesday the Commission has sat in the King's Robing Room, House of Lords, His Majesty having graciously placed this chamber at the disposal of the Commissioners.

All communications should continue to be addressed to the office of the Commission, 2, Queen Anne's Gate Buildings, Westminster, where Mr. Gilbert Stone, the Assistant-Secretary, will be in attendance.

A special conference of delegates of the Miners' Federation of Great Britain was held at the Central Hall, Westminster, on Thursday, February 27, and at the close a report was issued officially, stating that "it was decided unanimously by the Conference to take part in the Coal Mines Commission, and, after our President and Secretary, accompanied by Mr. Adamson (Chairman of the Labour Party), had seen the Prime Minister, it was agreed that half of the Commission will represent the miners. The question of the appointment was left to the executive.

"The strike notices will now expire on March 22, instead of March 15. This decision was also arrived at unanimously.

"It was also decided by the Conference to ask the Parliamentary Committee of the Trades Union Congress and the Labour Party to take up at once the question of demobilised men who are unable to find employment, or who are unable to follow their previous employment, so that adequate payment should be provided for them."

Speaking at the meeting of the Coal Mines Commission, held on Tuesday last, Mr. A. L. Dickinson, chartered accountant, a partner in the firm of Messrs. Price, Waterhouse and Co., Chairman of the Finance Board and Financial Adviser to the Coal Controller, gave figures dating back to 1888, showing the yield in tons per person employed for the five years ended 1893. The output was 282 tons per person, and for the five years ended 1903, when 776,680 persons were employed, the output was 288 tons per person. In 1907 there were 975,097 employed, and the yield was 289 tons per person, while for 1908 the figures were 972,233 persons, and the output dropped to 269 tons.

The Eight Hours Act came into operation in 1909, when the number of persons employed was 992,333, and the average output 266 tons. The number of persons employed had risen in 1910 to 1,027,539, but the yield dropped to 257 tons. There was no material change to speak of between 1911 and 1914. In the latter year the average get per man was 252 tons. In 1915 the number of men employed dropped by reason of the war to 939,000, having been, in 1913, 1,111,000. The get per man in 1913 was 251 tons. In 1915 it was 270 tons, and in 1916 the numbers were up a little, the number employed being 954,756, and the average output per man 260 tons. In 1917 the number employed was 1,006,000, and the average get per person 247 tons.

In 1918 the tonnage rate on the basis of the figures for the six months ended June was 245, and on the figures for the three months ended September 235 tons per man. The annual earnings per person on the figures for the first half of 1918 were 149*l.*, and on the figures for the three months ended September 160*l.* From January to June, 1918, the price of coal at the pithead was 20*s.*, and from July to September 24*s.* 10*d.* per ton.

At a recent sitting of the Court of Arbitration on Labour Matters, the arbitrators decided, in the matter of dockyard labour questions, that the "skilled labourers" in the dockyards who are employed on important productive work in the shipbuilding and engineering departments are to be titularly described in future in accordance with the class of work upon which they are mainly engaged; that no change shall be made in the existing system of interchangeability of the "skilled labourers" (however classified) between the several classes of works in accordance with the exigencies of the service; that if temporarily transferred to other jobs the men shall not suffer a reduction of pay; that the existing practice of up-grading labourers who display the necessary qualifications is not to be interfered with.

They further found that the claim made by the Amalgamated Society of Engineers had not been established. The claim referred to raised the question of the status of skilled labourers employed on milling, slotting, shaping and planing machines; the A.S.E. urged that, instead of the present variable rates paid these men, there should be adopted a flat rate of 37*s.* per week, plus war wages, this being the maximum rate paid to skilled labourers.

The Provisional Joint Committee set up by the National Industrial Conference on February 27, held its first sitting at the Central Hall, Westminster, last Tuesday.

The Minister of Labour opened the proceedings, and introduced the Prime Minister, who addressed the meeting. The Minister of Labour and the Prime Minister then withdrew, and Sir Thomas Munro, the Chairman of the Committee appointed by the Government, took the chair.

After a full discussion, and on a report of a sub-committee, a resolution, moved by Sir Allan Smith and seconded by Mr. Arthur Henderson, was unanimously agreed to. It reads:—

"That this Committee, in order that its work may be accomplished as expeditiously and thoroughly as possible, divide itself into three sub-committees, with the following terms of reference:—

"(1) To make recommendations concerning: (*a*) The methods of negotiation between employers and trade unions, including the establishment of a permanent Industrial Council to advise the Government on industrial and economic questions, with a view to maintaining industrial peace; (*b*) the methods of dealing with war advances; and (*c*) the methods of regulating wages for all classes of workers, male and female, by legal enactment or otherwise.

"(2) To make recommendations as to the desirability of legislation for a maximum number of working hours and a minimum rate of wages per week.

"(3) To consider the question of unemployment, to make recommendations for the steps to be taken for its prevention, and for the maintenance of the unemployed in those cases in which it is not prevented, both during the present emergency period and on a permanent basis.

"Unrest and output to be discussed by the whole committee at its next meeting on statements previously submitted by the parties."

It was agreed that the Ministry of Labour should circulate papers on a number of relevant questions, and that the Government should appoint a chairman for each sub-committee.

A time-table was arranged to permit of the report of the Joint Committee being circulated to all delegates to the Industrial Conference for consideration prior to a further meeting of that Conference on April 4.

Mr. F. W. Gilbertson, who was elected by the employers at the Industrial Conference on February 27 as a member of the Provisional Joint Committee then set up, is for reasons of health unable to accept the position, and the Committee have elected Mr. Edward Clark, of the Broughton Copper Company, Manchester, to serve in his place.

THE GOVERNMENT SCHEME FOR INDUSTRIAL RESEARCH.

THE Government, as already announced, have placed a fund of 1,000,000*l.* at the disposal of the Research Department to enable it to encourage the industries to undertake research. Much will depend upon the way in which this money is spent. The independence and initiative of the British manufacturer have contributed largely in the past to his success. After the war he will need all possible assistance in undertaking and developing research work as a means of enlarging his output and improving its quality. But if the help is to be effective, it must increase his independence and initiative. It must avoid chaining him to the routine of Government administration, however efficient. It must be so given as to enlist his active support. To the initiative of the manufacturer, the improvement of old and the discovery of new industrial processes in this and other countries have largely been due. It has been the co-operation of progressive industry with science which has led to the practical application of the results obtained in the laboratories of scientific men. The Advisory Council for Scientific and Industrial Research have, therefore, recommended, after consultation with manufacturers and others, that the new fund should be expended on a co-operative basis in the form of liberal contributions by the department towards the income raised by voluntary associations of manufacturers established for the purpose of research. By this method the systematic development of research, and the co-operation of science with industry, will be carried out under the direct control of the industries themselves. It is also hoped that the co-operation of the firms concerned in any one industry may enable research work to be undertaken which could not have been dealt with by individual firms.

All considerations point to the necessity for combination to this end. If the firms in an industry which are engaged in the production of similar articles, or alternatively if the firms in different industries which make use of the same or similar raw or semi-manufactured materials, will combine to improve these articles or materials, to discover new processes or to increase the efficiency of existing processes, the department will contribute liberally to a joint fund for this purpose. The fund for each industry will be expended by a committee or board appointed by the contributing firms in that industry, and the results obtained will be available for the benefit of the contributing firms.

The department realises that there will be many difficulties in the way. Some industries are large and well organised or their dependence on science is obvious, while others are either small, badly organised or are not obviously based on the application of scientific principles. Again, some industries are from their nature mainly interested in research because they are users of certain materials which are susceptible of improvement, and these materials are also used by other industries. Experience has shown that in some cases a Research Association may be established for the whole of a complex industry, whereas in others it is most convenient for only the firms engaged in a single section to combine to form an association. Generally speaking, it is difficult to combine in a single association both the makers and the users of any commodity, though there is one instance where the attempt to do so has been successful. It appears to be certain, however, from these considerations that some firms will wish to belong to more than one combination for research purposes, and that if wasteful effort is to be avoided, every possible means must be used to encourage co-operation between different research organisations as well as between the several firms within the same organisation.

But this will not exhaust the problems ahead. Some firms in an industry will be in a better position to make profitable use of the results of research than others. All firms in an industry are not equally alive to the possibility of improvement, and each individual firm has its own views as regards the measure of the advantage to be obtained from research work in its particular branch of industry.

All firms invited to join such an organisation as is contemplated are likely to ask themselves what they are going to get out of it. They would not be efficient businesses if they did not. The answer to this question ought to give an outline sketch of the way in which such an industrial research organisation would work. The means and method of its establishment will be described in later paragraphs.

It is anticipated that each firm subscribing to research organisation will have the following privileges:—

1. It will have the right to put technical questions and to have them answered as fully as possible within the scope of the research organisation and its allied associations.

2. It will have the right to recommend specific subjects for research, and if the committee or board of the research organisation of that industry consider the recommendation of sufficient general interest and importance, the research will be carried out without further cost to the firm making the recommendation, and the results will be available to all the firms in the organisation.

3. It will have the right to the use of any patents or secret processes resulting from all researches undertaken, either without payment for licences or at any rate on only nominal payment as compared with firms outside the organisation.

4. It will have the right to ask for a specific piece of research to be undertaken for its sole benefit at cost price, and, if the Governing Committee or board approve, the research will be undertaken.

It will be realised that no firm outside the organisation will have any of these rights. The documents and bulletins available for members of the organisation will not be published unless the controlling committee of the organisation decide that they shall be.

There are other privileges to which each firm subscribing to a Research Association will be entitled if the association decides, as several associations have already done, to establish a Bureau of Information. Everyone who has had experience of research is fully aware of the fact that useful discoveries usually take time to reach the stage at which they are available for commercial use. If for no other reason than this it will often be desirable for a Research Association to set up a Bureau of Information which will give to each of its members technical information relating to the industry. If this is done each firm will have the following privileges:—

1. It will receive a regular service of summarised

technical information which will keep it abreast of the technical developments in the industry at home and abroad. To do as much for itself any firm would have to employ more than one man on its staff reading and translating the technical press.

2. It will be able to obtain a translated copy of any foreign article in which it may be specially interested and to which its attention will have been drawn by the periodical bulletin.

The method of assessing the subscription of each firm will have to be determined in negotiation with each industry or section of an industry which may agree to combine for the purposes of research, but the intention is that firms should contribute on a basis proportionate to their size. Thus the small firm will contribute less than the large firm, yet it will have the same privileges, though as a rule it will not in the nature of the case have the same facilities for exploiting the results of research. The small firm will be more likely to use the benefits under heads (1) and (4) than the large firm.*

The department is advised that the best machinery for the purpose in view is the establishment of research companies limited by guarantee of a nominal sum (*e.g.*, 1*l.*) and working without profit, *i.e.*, without the division of profits among the members in the form of dividends. In order to assist industries in the formation of limited companies or associations of this kind, the Research Department has drafted a specimen Memorandum and Articles of Association† based upon the skeleton prepared by the Board of Trade for use in such cases. It is not intended to impose this specimen Memorandum and Articles of Association on industries desiring to establish Research Associations. The order in which the objects of the association are set out may need modification to suit varying circumstances, and the "objects" themselves may have to be varied by either excision or enlargement, but the intention of the draft has been to include, as far as could be foreseen, all those powers and activities which an association founded for the purposes of research might need to possess. At the same time, the nearer any draft Memorandum and Articles of Association can be brought to the specimen, the quicker and cheaper will be the departmental procedure.

Such associations, being limited liability companies working without profits, will be able to distribute beneficial information to their members without infringing Section 20 of the Companies' Acts; and if they are established in accordance with the provisions referred to, the subscriptions paid to them by contributing firms will, under a recent decision of the Board of Inland Revenue, be recognised by the surveyors of taxes as business costs of the firms and will not be subject to income or excess profits taxes. The income of the associations will similarly be free of income-tax.

Any such association will also be qualified to apply for grants towards its income from the Research Department under stated conditions,‡ though experience has shown that not all industries will wish to do so. In those cases where aid is necessary a Government grant will be given for a period of years to be agreed upon, not exceeding five, though it may be extended if funds are available and the condition of the industry calls for further aid. The contribution will be made in the anticipation that when the new organisations are once fairly launched on their career the need for direct State assistance will disappear, and British industry will be as self-sufficing in the field of industrial research.

The whole of the results of researches conducted by any Research Association will belong to the association itself, which will hold them in trust for the benefit of its members. The Government is, however, specially bound to safeguard the national interests where new discoveries are made with the assistance of Parliamentary funds, and accordingly, besides the powers it already possesses under the Patents and Designs Act, 1907, it will keep in its own hands two additional powers, which may be said to limit the absolute ownership otherwise reserved to the association—the right of veto in case any proposal is made by a Research Association to communicate any results of research to a foreign person or to a foreign corporation, and the right, after consultation with the association concerned, of communicating the results of discoveries to other industries for their use on suitable terms. The department will not, however, make any results obtained by a Research Association available to firms or individuals who are eligible for membership of that association but have not joined it.

It will be seen from this short description, and from a detailed study of these documents, that the policy of the Research Department is to delegate the prosecution of industrial research on a co-operative basis to the industries themselves, working through voluntary associations of firms engaged in producing similar articles, or using the same materials. It is hoped and anticipated that these associations will co-operate with each other in the solution of problems of common interest and the department intends to do its utmost to encourage such alliances. It is also anticipated that the associations will make every possible use of existing facilities for scientific research, whether at the universities and technical colleges, or at such central institutions as the National Physical Laboratory. There will be ample scope for all these agencies as well as for any special research institutes which the Research Associations may establish in future for their own purposes.

Department of Scientific and Industrial Research,
15, Great George-street, Westminster, S.W. 1.

* The "Method of Subscription to Research Associations" is discussed in "Research Association 4," which may be obtained from the department.

† Draft Memorandum and Articles of Association for Trade Associations for Research ("Research Association 2").

‡ See "Research Association 3."

INTERNATIONAL ELECTROTECHNICAL COMMISSION.

THE cessation of hostilities and the advent of peace has given an impetus to reconstruction and more peaceful pursuits than have occupied the world during the past 4½ years. The Central Office of the International Electrotechnical Commission has been maintained during the years of war through the generous assistance of the National Committees, with which it has been in direct communication, and is now considering the question of reorganisation of the whole Commission. In order to carry this into effect, however, it will be necessary to have a plenary meeting of the Commission when various important matters will be considered; such as the question of the enemy countries, which before the war took part in the work of the Commission and, also, filling the gap which time and other circumstances have unfortunately made in the membership of the various committees.

In the question of nomenclature, for instance, it will be difficult to replace such a delegate as the late Dr. S. P. Thompson, who had endeared himself not only to Englishmen, but to everyone with whom he came in contact. However, another delegate will have to be appointed to represent the British interests.

In regard to the rating of electrical machinery, during the war Europe has not been able to devote much attention to research work and, consequently, there has not been so much progress in regard to our knowledge of insulating materials as in the case of America. Moreover, certain misunderstandings have arisen owing to the fact that both the American and British Committees have, with the very best intentions, slightly exceeded the limiting temperatures, in certain cases, already adopted by the International Electrotechnical Commission. This has given rise to misapprehension on the part of the French Committee, and it has been thought wise to arrange for a meeting of the Special Committee on Rating, in Paris, just after Easter, rather than wait for a full meeting of the Commission. In this way it is hoped that the difficulties will be surmounted and foundations laid for a plenary meeting of the Commission, which will consider the question of reorganisation of the whole of the work to be undertaken. The Central Office is, at the present moment, engaged in arranging the meeting of the Special Committee, which consists of representatives of Belgium, France, Great Britain, Italy, Sweden, Switzerland and United States of America.

In so far as the actual work before the Commission is concerned, the question of graphical symbols in electrotechnics has been under discussion in America, Great Britain and Italy, and a large amount of preparatory work will be at the disposal of the Special Committee on Symbols.

It is probable that an international standard for the resistance of aluminium will be adopted in the same way as has been done for copper. The French Committee are also suggesting that the International Electrotechnical Commission should take up the question of screw lamp sockets and holders. It is becoming more and more important in all international work that a clear-cut distinction be made between standards and detailed specifications.

One of the chief points to be remembered in nominating delegates is that continuity of thought should be preserved as much as possible, as it is only in this way that success can be assured. It is, therefore, urged that in making nominations, this point shall be kept clearly in view, and delegates appointed who are prepared to keep closely in touch with the subject under discussion. Standardisation and production are so intimately linked together and the question of foreign trade is so important to the electrical industry, that a good representation on the part of the British electrical industry should be assured.

BUILDING BRICKS.—The Minister of Munitions has suspended, as from February 28, the operation of the Building Bricks Control Order, 1918, dated April 5, 1918, in so far as it prohibits the sale and delivery of building bricks except under and in accordance with the terms of a permit issued under the authority of the Minister of Munitions.

THE LATE MR. MAX O. WURL.—We regret to have to record the death, which occurred at his residence, Newcastle-on-Tyne, on February 18, of Mr. Max O. Wurl. Mr. Wurl joined the firm of Wigham Richardson and Co. (now Swan, Hunter and Wigham Richardson, Limited) in 1900, as technical assistant to the late Mr. John Tweedy, the partner in charge of the engineering branch. For fifteen years Mr. Wurl was chief designer at the firm's Neptune Engine Works, where he had charge of the scientific and experimental department. A large amount of important research work was carried out under his direction, and in this connection it may be mentioned that he was responsible for the long series of experiments with the self-propelled model of the Cunard Steamship Company's vessel "Mauretania," to which much of that ship's success is due. Important work was also done under his supervision at the Neptune Works in developing the internal-combustion engine for ship propulsion; this led to the construction of the Neptune Diesel engine, a slow-running, two-cycle marine engine, which has proved most successful. Mr. Wurl also carefully analysed and co-ordinated the voyage and trial-trip data of the many ships and engines built by the firm, thus securing series of valuable information which materially helped to establish the high efficiency of both ships and engines. His loss is a serious one to his immediate associates, and to the marine engineering profession as a whole. His personal qualities had won for him a wide circle of friends.

NAVAL ENGINEERS.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with much interest the two letters, one by "An Engineer," and the other by "Naval Engineer," that have appeared in recent issues of ENGINEERING. While I am heartily in agreement with them as regards the improvement of the standing of engineers in general, one or two of their statements are misleading.

To talk of 33 engineers on the Olympic, in the sense that "An Engineer" intends to be believed, is of course absurd. What really happens is that when a ship of the mercantile marine is taken over, by the Admiralty, all her engineers are given commissions, but this does not relieve them from doing any repair work necessary, or of ordinary routine watch-keeping.

To make the comparison between the Tiger and Olympic, on these grounds, the whole of the Tiger's warrant engineers and also her chief and engine-room artificers should have been included in the Tiger's engineering staff. This would have been a total of between 50 and 60, not three as stated by "Engineer."

"Engineer" also states that the chief source of supply for engineer officers will be from the boy artificers now trained by the Admiralty. What about the men recruited into the Navy from outside sources as engine-room artificers, directly their apprenticeship outside is completed. Many of these have had a training equal at their age to any, but of course they are not disciplined like the boy engine-room artificers.

The rating of "Mate," the route through which young ambitious engine-room ratings must go to reach ward-room rank, was created specially for the boy artificer so that his training should not lead him into a "blind alley." There are many others, however, who passed the necessary examination and qualified as "Mates." These are amongst the best engineers in the service to-day. Is it not a fact that like all other kind of Government training, the training of boy artificers is extremely costly, and that it costs as much as it does to pay an artificer drawn from outside for the first twelve years of his service? Both "Engineer" and "Naval Engineer" appear to be sore about the standing of an engineer in the ward room. The remedy lies with themselves. How many engineers will support one of their own branch, when he is on the quarter deck for some trivial crime; they earn for their own branch a bad impression. The responsibility of the naval engineer is no heavier than that of any other engineer; in fact, it is less. The naval engineer has under him trained men who have been specially trained for their work and have long experience.

Thus the boiler rooms are in charge of one or more chief stokers; he has special water-tenders. His engine-room watch-keepers are also reliable and responsible. In fact, every department is in charge of a thoroughly experienced practical man.

His repairs are of a minor character. He has an up-to-date workshop fitted with modern machine tools, and a good reservoir of skilled labour upon which to draw. It rests with "Engineer" himself whether his job is easy or hard. He makes his own bed and must not grumble if it is not to his liking. Regarding the granting of decorations it must be remembered "Engineer" is an engineer and not an "ornamented rainbow." If he is anxious for distinctions he should have joined a fighting service.

Regarding the remarks on lieutenants "E" they have little to grumble at, they are getting an excellent, free, engineering education.

The mate has had to fight for his, and his path is full of prickles, particularly when his chief is a non-believer in the rating. All luck to the engine-room artificers who are endeavouring to be placed on a level footing with merchant service engineers, and who are asking to be known as assistant engineers in future.

I am, Sir, yours faithfully,
H. G.

80, Clyde-road, Tottenham, N. 15,
March 2.

"COAL SAVING AND SCIENTIFIC CONTROL OF BOILER PLANT."

TO THE EDITOR OF ENGINEERING.

SIR,—When I first formulated the rate of combustion in British thermal units per unit of air used, I was ignorant of any reason why efficiency of combustion should follow the rule of inverse proportion to the number of heat units liberated. At the present time I am just as ignorant, but my observations have, in the interval, been confirmed by many tests.

I believe there is a possibility of explanation in the observed fact that at certain temperatures carbon will not combine with the oxygen in air to produce carbon dioxide, however favourable the quantity of air may be toward such a combination. At the same time I do not think the knowledge at present available regarding this peculiar effect is sufficient to make the explanation a simple matter of chemical arithmetic.

Until the matter is taken up by some authoritative committee of our engineering institutions and absolute values ascertained your readers will be quite safe in using the values I gave in your issue of 31st ult.

Somewhat differently stated these are as follow: With any particular fuel, and a rate of firing suited to the fuel, every boiler develops its highest thermal efficiency when the rate of combustion is 620 British thermal units per pound of air used.

Every increase in the rate of combustion is accompanied by a corresponding increase in the output and a corresponding decrease in the thermal efficiency until the rate becomes 750 British thermal units per pound of air used.

At rates of combustion between 750 British thermal units and 780 British thermal units per pound of air used output and thermal efficiency are almost stationary.

At rates of combustion beyond 780 British thermal units per pound of air used combustion is incomplete, output and thermal efficiency decrease more or less rapidly.

At rates of combustion less than 620 British thermal units per pound of air used combustion becomes uncertain, output and thermal efficiency decrease more or less rapidly.

As an example, with coal of a calorific value of 13,500 British thermal units per pound, the pounds of air per pound of coal for maximum output are $\frac{13,500}{750} = 18$ and for maximum efficiency are $\frac{13,500}{620} = 21{\cdot}77$.

For all practical calculations combustion is theoretically complete at an assumed rate of 1,500 British thermal units per pound of air used, i.e., $\frac{13,500}{1,500} = 9$, thus confirming my 100 per cent. excess air statement.

Since writing the above I have your issue of 28th ult., with Mr. Casmey's letter suggesting, in Table B, that steam boilers can be, and are, economically operated with only 50 per cent. of excess air. As that excess of air gives a rate of combustion equal to 1,000 British thermal units per pound of air used the pounds of air per pound of the fuel above would be $\frac{13,500}{1,000} = 13{\cdot}5$.

It can safely be asserted, that neither Mr. Casmey nor anyone else has ever operated a boiler economically on coal fuel with that quantity of air, or at that rate of combustion. Both of Mr. Casmey's tables are based on the hoary tradition that every pound of coal requires for its theoretically complete combustion 12 lb. of air. As that has been exploded long ago it is scarcely necessary further to discuss it. Mr. Casmey's suggestion that reducing the grate area and increasing the rate of firing automatically cuts down the air supply is rather ingenious, but he has forgotten to take into account the increased pull of the chimney due to increased temperature of the waste gases.

As I have not in any of my letters suggested that an unsuitable rate of firing should be used the extracts from letters of boiler users certifying the improvement effected by adopting a suitable rate of firing do not call for any comment. I have dealt with the air supply.

Yours truly,
JAS. DUNLOP.

190, Bellfield-street, Dennistoun, Glasgow.
March 1, 1919.

APPLICANTS FOR SITUATIONS.

TO THE EDITOR OF ENGINEERING.

SIR,—Will you please allow me to draw attention to a practice which ought to cease, viz., that of engineering firms advertising vacancies, and after having made a selection merely informing applicants by means of a curt advertisement, that "the position has been filled"?

While demobilisation is proceeding many men who have helped to preserve the works of the firms in question are going to considerable trouble and expense in sending in applications. As competition is admittedly keen they send testimonials, photographs, and other documents representing time and money.

For a firm to advertise under cover of a number and then to pitch these into the W.P.B. is simply trading on the importunity of men who deserve the best the country can offer.

Yours, &c.,
"FED UP."

CRANES FOR SHIPYARDS.

TO THE EDITOR OF ENGINEERING.

SIR,—I read with interest the description in your issue of February 14 of the Toplis luffing cranes for shipyards, and the comparison of the jib and cantilever type of cranes as applied to shipbuilding. As designer of the first cantilever tower crane equipments for British shipyards, and of numerous other crane equipments of various types, now in use in shipyards and dockyards, might I be allowed space for a few general remarks on the subject of shipyard cranes.

For average merchant shipbuilding practice, a clearance of 75 ft. to 100 ft. is generally required from ground line to under side of jib or crane structure, with jib in lowest position, and a range of lift of, say, 85 ft. to 110 ft. from ground to centre of hook. In most large shipyards, it has been found necessary to arrange the spacing of adjacent building berths as close together as possible to economise space. Frequently a width of 12 ft. to 15 ft. only is available for the crane structure and a narrow gauge, or standard 4 ft. 8½ in. gauge track, for conveyance of materials between berths; in which case travelling cranes on ground rails are out of the question.

Under these conditions the design of suitable crane equipment is no simple problem. High initial cost in most cases precludes the use of large continuous crane gantry equipments. Cantilever tower cranes, high pedestal jib cranes, or the improved types of ship building derrick cranes, form economical and efficient equipment, each with its own special features, and all of which have given equally good results in practice.

Where it is desirable to complete vessels with upper mountings, such as funnels, ventilators, or masts, &c., before launching, the high luffing jib crane has some advantages, as by luffing the jib to a small radius, such high obstructions can be avoided. With a little care and ingenuity in handling, such work can be accomplished with the cantilever tower crane also. Cranes of this type in use in some yards have a clearance height under the cantilever of 136 ft. above ground.

No difficulties in slewing against high winds, as suggested in the article on page 208, have been experienced with well-designed cantilever tower cranes of normal proportions. Cantilever cranes of similar capacities to the jib cranes illustrated, but with 120 ft. range of lift above ground, have been in constant use for the last six years in which only 8 h.p. to 10 h.p. motors are satisfactorily employed, giving much higher slewing speeds than those quoted for the jib cranes. With cantilever cranes of abnormally large radius, such as 120 ft. and 130 ft., any difficulty in slewing against high wind is easily overcome by providing wind shields on the tail end of cantilever, to reduce the unbalanced wind moments of the long and short arms of the cantilever.

When working through staging, hatchways, or very confined spaces, single fall hoisting rope is preferable. A long single wire extension sling is all that is required when using a snatch block lift. Properly spaced and proportioned multi-fall ropes and snatch block give no trouble due to twisting of ropes, even with 120 ft. or more range of lift.

High pedestal travelling jib cranes, or travelling cantilever tower cranes, form a very economical crane equipment in first cost, where space between berths permits of a 20-ft. to 25-ft. gauge crane track in addition to the usual clearance required, for staging. There has recently been a tendency in some quarters to perpetuate types of cranes with abnormally large radius of 120 ft. or 130 ft. and reducing the number of cranes per berth to a minimum.

Even with high-speed cranes there is a limit to the handling capacity of the individual crane, governed more by the time the crane remains more or less stationary with load suspended during operations, or during slinging, than by the speed of the crane movements. Rapidity of output, generally a prime factor, will be much more readily attained by the use of a larger number of cranes of smaller radius of, say, 80 ft. to 100 ft.

WM. R. STEELE.

H.M. Dockyard, Portsmouth, 22 January, 1919.

FATE OF THE GERMAN FLEET.

TO THE EDITOR OF ENGINEERING.

SIR,—I see it is suggested that the German battleships and cruisers should be taken out to the Atlantic and sunk in deep water. If it is not economically possible to break these ships up and use the material of which they are built, surely there are better purposes to which they could be put as hulks, than by sinking them in deep water?

For instance, would it not be possible to make protected sea areas for fishing and other craft in home waters or in the waters of some outlying colonies where breakwaters cannot at present be afforded. They could be partially filled with concrete and sunk near the shore. By the time their hulls had rusted away, sufficient funds might have been accumulated from harbour dues to pay for superior breakwaters.

Again, in the deltas of some of the great rivers of the world, and to help to scour away bars, these ships, after being partially filled with concrete, might be sunk and used to train the flow of the water and so improve navigation.

A further use suggests itself; it is now no longer a secret that steamers were sunk in some of our harbour entrances to make them safe against the entrance of submarines and torpedo attack. Why should not the entrances of some of our land-locked harbours be partially filled by the hulls of these ships so as to reduce the depth of water to such an extent that submarines could not attempt an entrance at depth, but be forced to rise to the surface before attempting to come in. There must also be in the world certain channels that it would be well to keep blocked entirely near the entrance to the Baltic. Why not use them for such a purpose.

If the ships were dismantled, could they not be used for conveying oil in bulk to outlying ports or used for the storage of oil fuel in coaling harbours. In the future oil will be needed at all the coaling stations of the world.

Again, inasmuch as the Channel Tunnel is bound to be constructed some day and it is not known at the present time what the relative levels are between England and France, why should not some of these ships be sunk in the Channel and used to ascertain such differences of level between Great Britain and Europe. A method of doing so would suggest itself; namely, to sink them, with properly constructed steel towers upon them, at intervals across the Channel and determine what is the correct level between the two lands. This is a use to which these ships might be put, and so realise some benefit to the whole of mankind! The towers, when done with, could be blown away quite easily.

We cannot afford, I submit, to waste anything that is the least useful at such a time as the present.

Yours faithfully,
E. W. MOIR.

10, Victoria-street, Westminster, S.W.,
February 28, 1919.

TO THE EDITOR OF ENGINEERING.

SIR,—The suggestion put forward by Messrs. Baker and Hurtzig in your issue of February 28, for turning to a useful purpose the late German fleet, is certainly interesting, but it appears to me that if used as suggested, to be incorporated in the foundation of a breakwater or harbour wall, a somewhat large and dangerous "void" would result at these spots unless a considerable amount of expensive strengthening work were first carried out on the hulls.

In the above case we should at least know that the late German fleet was now "down and under," but could not some more useful purpose still be found for it.

Surely, without very much modification, these vessels, and still more particularly the late U-boats, might be used by the Admiralty as floating or underwater storage tanks for petrol or crude oil?

I am, Sir, yours faithfully,
H. B.

Golders Green, N.W. 4, March 5, 1919.

COHESION IN RIVER MUD.

TO THE EDITOR OF ENGINEERING.

SIR,—In the course of some recent computations as to accretion and scouring, a serious error in the text-book methods came to my notice. It is customary to assume that the velocity required to roll or transport small particles decreases indefinitely with the size of the particle, but as a matter of fact a stable bed is possible in mud as well as in fairly coarse sand with a bottom velocity in both cases of, say, 3 ft. per second. This is undoubtedly due to the cohesion of the mud, and is concomitant with its fineness, so that there is a minimum velocity of erosion for all river beds. If we compute the drag per unit area on the bed from the usual rules for fluid friction it will be found that when the particles are small the force per particle may be as little as 10^{-6} dynes. This is about the cohesion bond between two molecules, so that the whole particle (perhaps several million molecules) can be retained by one pair of cohesing molecules.

This explains the well-known stability of mud channels which has been observed in Egypt, India and China.

Yours faithfully,
HERBERT CHATLEY.

Whangpoo Conservancy, Engineer-in-Chief's Office,
Shanghai, January 13, 1918.

KEIGHLEY LATHE DESIGN COMPETITION.—The Keighley Association of Engineers announce that they have opened a lathe design competition, particulars concerning which can be obtained from Mr. Robert Hudson, Hon. Secretary, South-street, Keighley. A first prize of 100 guineas and a second prize of 25 guineas will be given for the best design of an 8½-in. centre, all-geared, sliding, surfacing and screw-cutting general-purpose lathe, with an 8-ft. straight bed.

THE INDUSTRIAL RECONSTRUCTION COUNCIL.—A conference on "Labour Conditions in Relation to Future Industrial Prosperity" will be held under the auspices of the Industrial Reconstruction Council, on Tuesday, the 11th inst., at 6 p.m., in the Hall of the Institute of Journalists, 2 and 4, Tudor-street, E.C. 4. The chair will be taken by Major the Hon. Waldorf Astor, M.P., and the opening address delivered by Captain James O'Grady, M.P., secretary of the National Federation of General Workers. Questions and discussion will follow No tickets are necessary.

STEEL PRICES.—The Minister of Munitions has issued Notice No. 34, giving the following increases in the maximum prices of steel for home sales as from March 1, 1919. The prices are in each case net f.o.t. makers' works: Mild steel billets, blooms, slabs, sheet and tin-plate bars, ordinary quality, 12*l.* 5*s.* per ton; small angles, tees and flats, extra list E (*re* rollers only), 17*l.* 5*s.* per ton; small rounds, squares and hexagons, extra list G (*re* rollers only), 17*l.* 5*s.* per ton. The steel makers price for small angles, rounds, &c., remains unchanged at 16*l.* per ton.

LAND SURVEYING AND LEVELLING.—A course of lectures at the London County Council Westminster Technical Institute, Vincent-square, S.W., including office practice, and field work, will commence on Tuesday, the 11th inst., at 7 p.m., and continue until about the end of June. It is suitable for those engaged in engineering, surveying and architecture, who require a theoretical and working knowledge of surveying, and who are preparing for the examinations of the Surveyors' Institute, the Institution of Civil Engineers, &c. All apparatus and instruments are provided for field work, which will be carried out on Primrose Hill on Saturday afternoons; and students will work in small groups so that all will have the necessary practice with the instruments. The syllabus is as follows: Preliminary and chain surveys; the theory, structure and adjustments of the principal surveying and levelling instruments, and the principles of their employment under various conditions; surveys of roads, estates, railways, canals, reservoirs, &c.; setting out curves; plane table surveys; contouring; calculation of areas from plotted survey and of quantities in cuttings and embankments; and, if time permits, determination of meridian, latitude and longitude. The lectures will take place on Tuesdays from 7 p.m. to 9.15 p.m.; the field work or office practice on Saturdays from 2.30 p.m. to 5.30 p.m. Instruction in practical trigonometry will be given on Tuesdays from 6 p.m. to 7 p.m., to those who desire this course. The principal is Mr. J. Stuart Ker, B.Sc., A.M.Inst.C.E.; and the lecturer and instructor, Mr. E. Sprague, A.M.Inst.C.E. The fee for the course is 5*s.* Students already in attendance at the Institute are admitted free. The course in reinforced concrete at the same Institute is running very successfully, with over 40 students in attendance. On Saturday last, a considerable proportion of them visited the Concrete Products Exhibition at Grosvenor-road organised by the Associated Portland Cement Company, where they were able to see illustrations of reinforced concrete products applied to railway and general engineering.

SOME MODERN TENDENCIES IN SHIPBUILDING.

MR. FREDERICK J. STEPHEN, chairman of the Technical Committee of the British Corporation for the Survey and Registry of Shipping, at the annual meeting held at Glasgow, reviewed some of the tendencies in shipbuilding due to war and other conditions. He said the committee had found it advisable to prepare rules for the construction of wooden ships. The building of wood ships had been revived as a war emergency measure, but the impetus thus given to it was almost certain to stimulate its regrowth in countries where timber was plentiful and cheap, and where comparatively small craft were in demand. The committee based their rules on the admirable rules of the Registro Navale Italiano. They did not think it waste of energy to modernise rules for the construction of the oldest type of ship, nor in this case to adhere to some extent to the oldest basis for scantlings, viz., numerals. An interesting development of wooden shipbuilding had engaged the attention of the committee in the case of the laminated wood ship, where the designer, Mr. Nicholson, had produced a wood structure with wide-spaced frames and a shell which was practically homogeneous.

The shipbuilding world had been coquetting with the idea of reinforced concrete for ships. For some years before the war their committee had evidence of increasing interest in the subject through designs submitted—chiefly by Continental designers. War efforts had provided in some months the material for as much experimental data of this type of construction as would probably have accrued in as many years of peace. There had not yet been time to acquire service data, but there had been an assimilation of technical ideas which gave hope that structural strength was being based on sound foundations. The application of electric welding to the framework of the reinforcing steel had already caused an advance in economy, efficiency and possibility of commercial success. Practical opinion was also hardening to the view that the original conception of casting the whole hull in one was not likely to compete economically with systems in which parts were cast separately and afterwards joined together. Some experienced concrete engineers maintained that no joint of this character could be made watertight—that a monolith was the only practicable ship—while others maintained the contrary. If it were shown that satisfactory jointing was easily possible, then the line of development would be towards methods which resembled the fabrication of steel ships, where as many parts as possible would be cast in one mould and afterwards assembled.

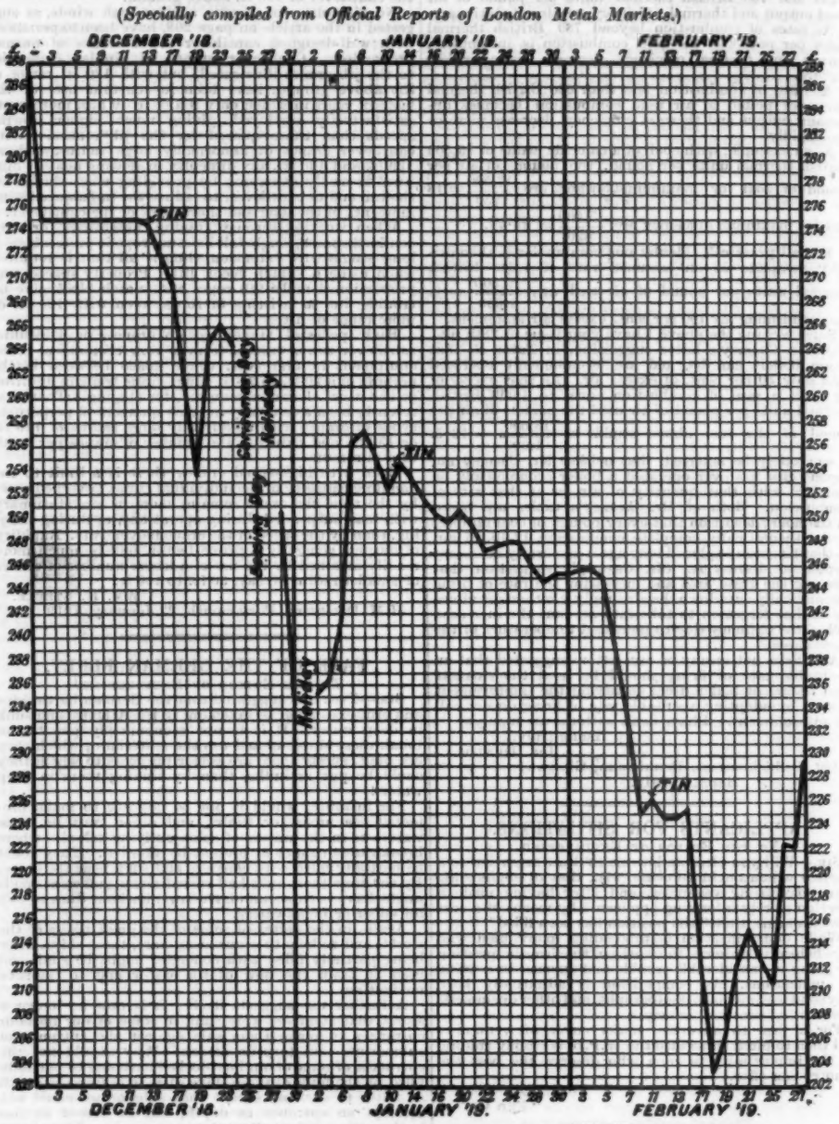
Amid the experience gained in the hard school of war, they had found confirmation of the views he had before expressed on the question of fitting expansion joints in long ranges of midship superstructures. The Alsatian had returned to her builders after her period of service as the Admiral's ship of the Armed Merchant Cruiser Squadron, during which the conditions must have been more severe than in peaceful trade. The fact that her double range of continuous deck-houses had stood up to these conditions proved the truth of the contention that expansion joints were unnecessary, and that the structures could be designed to do their work more satisfactorily without them. He was glad to find that designs for ships of this class which were now coming forward had the ordinary main hull construction carried up to the promenade deck, leaving only one range of deck-houses. This was a reform which added much to the efficiency of the hull and was worth the sacrifice of an open-air space which was not very much appreciated by passengers.

Mr. Robert Clark, the chairman, who presided, said that their 1913 record of work amounted to 343,000 tons; that of 1914 to 221,000 tons; that of 1915 to 105,000 tons, and that of 1916 to only 40,000 tons. In 1917, however, there was an increase of 154,000 tons, and last year the total reached 262,000 tons. In the initial stages of the programme of standard ships full recognition was given to the views of their society as to the strength and arrangement of the structure of the ships, the great majority of which had been built to plans agreed between the British classification societies, and were an embodiment of their joint views as to strength and simplicity of construction. Adding to their 1918 record of 262,000 tons the ships supervised for the Admiralty, amounting to 77,000 tons, they had a total of 339,000 tons, or practically the same as in 1913. But there had been a great difference, not only in the number of ships surveyed but in the nature and extent of the work and the responsibilities of the surveyors, who acted as representatives of the naval side of the Admiralty on the auxiliary craft and had to carry out the duties of an owner's superintendent on the merchant vessels. The committee had therefore had to increase their staff by 50 per cent. over that required in 1913, and to open their own offices in Aberdeen, Dundee, Londonderry and Toronto. They also appointed electrical engineer surveyors and surveyors experienced in reinforced concrete construction to meet the new conditions which had been created. The total number of auxiliary vessels surveyed for the Admiralty amounted to 313.

They had now on their books contracts for over 600,000 tons, which was much the largest volume of work he had had occasion to mention at their annual meeting. This showed that there was ample work to be done in the shipbuilding yards, and every prospect of continuous employment for all classes of labour for a considerable period, if the present condition of unrest could be got over. Other countries were developing their shipbuilding resources, however, and we must realise that we could not hope to hold our pre-eminent position unless we settled down to steady work. The reconditioning of ships which had been used for war purposes was proceeding, and it was natural that the Board of Trade should take the opportunity of this work being done in order to improve their bulkhead arrangements. It would surely be a convenient arrangement to place this work in the hands of the society under whose inspection the ship was built, and whose surveyors would be in attendance in any case. The additional data as to the strength of bulkheads which had been put in the hands of the societies through bitter experience should now be used, and full weight given to their views as to what was required.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



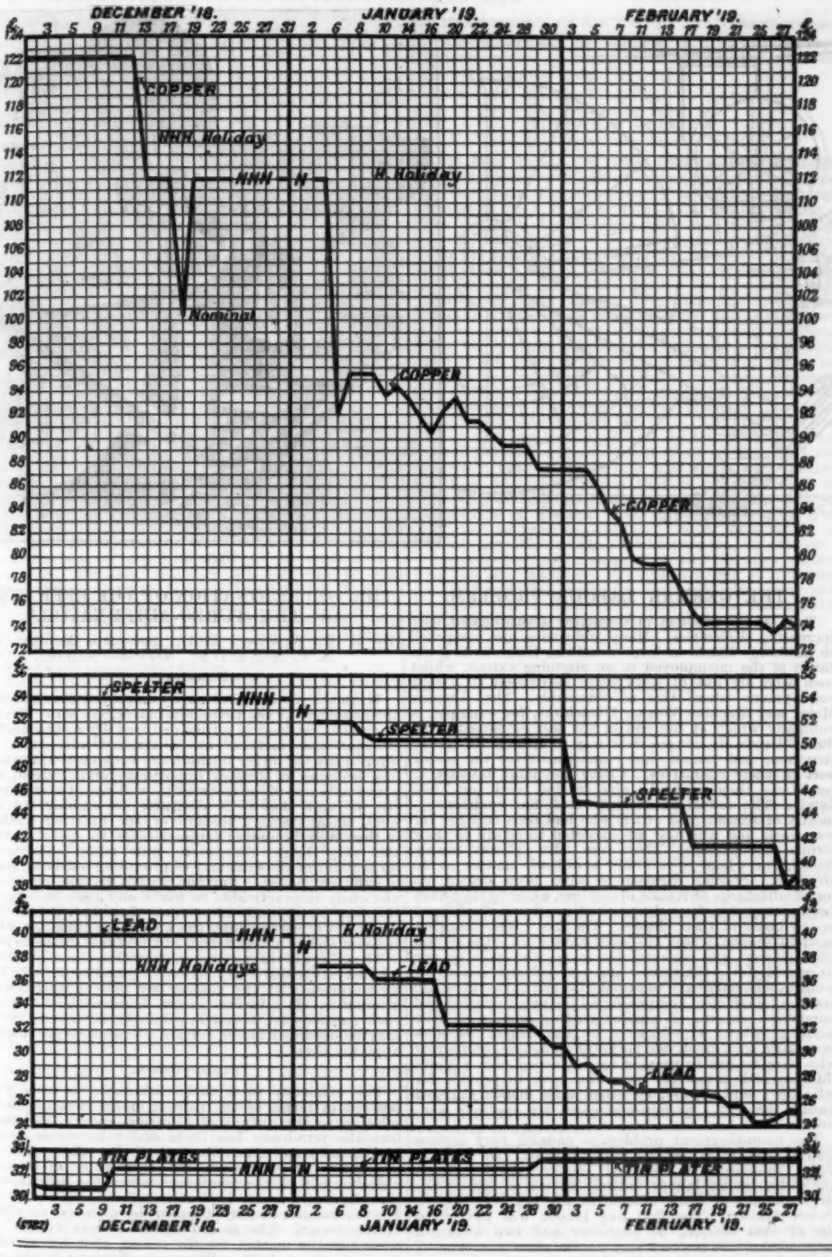
NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig-iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. (For official regulations see page 45, vol. cii.) A new series of prices for iron and steel has been issued, and appeared on page 646 of our issue of December 6, and on page 23 of our issue of January 3. The Minister of Munitions has also issued certain regulations controlling the prices and dealings in non-ferrous metals; these restrictions were removed on December 17.

COAL SUPPLIES, EXPORT, AND PRICES.—It has been announced that Sir Evan Jones, Bart., has, at the request of H.M. Government, consented to accept the appointment of Controller of Coal Mines in succession to the late Sir Guy Calthrop. Sir Richard Redmayne and Mr. A. Lowes Dickinson will continue to act as the principal technical and financial advisers to the Controller, and Mr. F. Pick will, as hitherto, deal with the distribution of household fuel. Mr. W. A. Lee will continue to be secretary of the department, and will deal with questions of export and prices as before. A further announcement states that arrangements having now been completed for the merging of the duties of the Coal Exports Committee with those of the Coal Controller, the Coal Exports Committee will be dissolved as from to-morrow. Applications for licence (which may continue to be made on the existing forms) and all correspondence which cannot reach the Coal Exports Committee or the War Trade Department (Coal Division) by to-morrow, should accordingly be addressed to the Coal Mines Department (Export Branch), Holborn Viaduct Hotel, London, E.C. 1. Telegraphic address: Export Coalcontro, London.

REFRIGERATING MACHINES.—We learn that Messrs. Peter Brotherhood, Limited, of Peterborough, have commenced the manufacture of refrigerating plant on the CO_2 and NH_3 systems. The former will be for marine purposes and the latter, of course, for land purposes. The firm have already been known for many years as large manufacturers of compressing machinery of various kinds.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



FURTHER RISE IN THE GERMAN IRON PRICES.

"How will this end" is the comment in a leading German paper, to the last rise in the quotations for iron products decided upon at the recent meeting of the Steel Union. A further rise was anticipated, but no one appears to have expected such a formidable increase in the prices. Opinions are understood to have been divided, it being urged against a further rise in the quotations, that it would simply mean fresh demands from the men for still higher wages. Prices for some commodities have now risen to 4½ times what they were at the beginning of the war, as will appear from the subjoined table :—

	August, 1914. Marks per Ton.	March, 1919. Marks per Ton.
Bundles (Kuüppel) ...	95·00	400
Girders	110·00	420
Bar iron	93·50	435
Blocks	82·50	385

The most recent increase, just agreed upon, amounts to 100 marks per ton for the four products in question, and 125 marks for hoop iron (present price 490 marks), and the prices are now twice as high as they were eight weeks ago. In this connection it is pointed out, that formerly large consumers, such as the rolling mills and the building trades, raised a strong opposition, when a rise of 5*s.* per ton was talked about. Yet the works, in their last statement, maintain that the increase in the quotations does not by a long way reach the cost of production. It would seem that the German industry has been in the habit of making similar statements during the war, statements which the subsequent brilliant balance-sheets have placed in a peculiar light. More especially as regards girders, much apprehension is being expressed at the huge increase at a time when the building industry, which has been almost at a standstill during the war, might be expected to experience a much-needed revival.

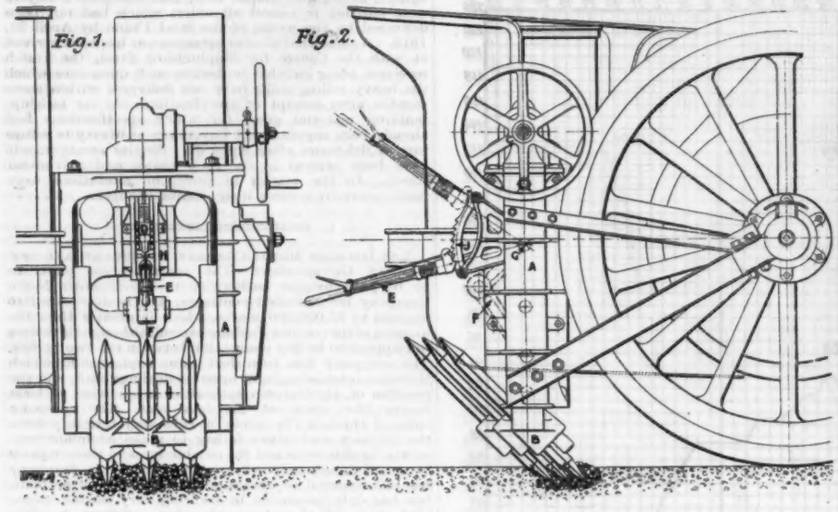
The present disturbed state of the German iron and steel industry has naturally interfered with the export trade in an unsatisfactory manner. As regards German export to Holland, negotiations have recently been carried on at The Hague between Dutch importers and the representatives of the German combines in question, the Steel Union, the Shipbuilding Steel Centre, the Black Plate Union, and the Export Union of German Galvanisers, the negotiations referring more to the completion of current contracts than to fresh agreements. On the whole it was agreed that the existing contracts should be maintained, and the reason, that deliveries were so far behind, was attributed to the marked preference given to the home market at the expense of the foreign market. Since the revolution, labour conflicts, shortness of raw materials and transport difficulties have further tended to minimise deliveries, some works having had to close up entirely. It was agreed, as regards shaped iron, that the Dutch buyers were entitled to cancel all orders which had not been delivered by the works of the Steel Union by April 30, 1919. A somewhat similar arrangement has been arrived at with the Centre for Shipbuilding Steel, the Dutch receivers being entitled to decline such quantities which the heavy rolling mills have not delivered within three months after receipt of specification. As far as shipbuilding material goes, for which specifications had already been supplied, the buyers are at liberty to refuse further deliveries after April 30. Similar arrangements have been arrived at for their plates and galvanised sheets. In the matter of price, no alterations were made apart from some insignificant changes.

THE DAIMLER MOTOR COMPANY, STUTTGART, AND THE GERMAN GOVERNMENT.—The compensation paid, or to be paid by the authorities to the Daimler Motor Company for cancelled contracts, &c., is now stated to amount to 32,000,000 marks, which is greater than the amount of the company's share capital, although there does not appear to be any connection between the two figures. The company has furnished some explanations which throw an interesting light upon its dealings with, and the position of, the German authorities in question, at least during the whole of the last year. The company suffered through the whole of 1918 very seriously from the military authorities failing to make adequate payments for deliveries and the indebtedness to the company increased incessantly. Since May, 1918, the company has endeavoured to obtain some payments on account, but has only succeeded in securing very modest sums, with the result that it was placed in a difficult financial position. The company's indebtedness for materials increased to a serious extent, and they had many applications for payment; also legal proceedings were taken in some cases, and bank credits had to be provided. The present large payments to the company by the military authorities in the first instance refer to old outstanding accounts, and the money has mostly gone straight to the company's creditors.

ROUTINE EXPLOSIVE TESTS OF THE UNITED STATES BUREAU OF MINES.—In Technical Paper 186 of the United States Bureau of Mines, S. P. Howell and J. E. Tiffany describe the physical tests which have been developed during the nine years of the working of the Explosives Section at Pittsburg for examining explosives, for use in gaseous and dusty mines, as well as blasting agents for metallurgical mines, tunnels, quarries and other purposes. The paper was compiled for the guidance of the staff, but is published in response to numerous inquiries addressed to the Bureau. The staff consists of the explosives engineer, two assistant engineers, one of which is generally engaged on research work, and three testing engineers, mostly juniors, two shotfirers and a clerk. The paper, of 63 pages, includes about 20 pages of conversion tables and gives also advice on the general treatment of explosives. Boxes should be opened with wooden mallets and hardwood wedges and be arranged so that the cartridges lie horizontally; the floors of magazines are regularly swept, and if stained with nitroglycerin, scrubbed with a solution of 2 lb. of sodium sulphide in half a gallon of water and as much alcohol, with the aid of a stiff broom or mop. In the thawing of explosives the water must be heated in some other receptacle, not in the water compartment of the thawer, lest any nitroglycerin left be decomposed; the temperature of the water must not exceed 125 deg. F., that is, not be uncomfortable to the hand. In performing the tests the testing engineer must keep the safety plug in his possession to be sure that the circuit remains open till everything is ready. Misfires may be due to short circuits (faulty insulation) outside the bore hole, or to defective detonators; an interval of at least 15 minutes has to be allowed after a misfire lest there be delayed shots or hang fire. After giving general instructions as to the physical examination of the samples and the way of entering the results, some tests are described in detail. The rate of detonation is determined by suspending one cartridge, or an explosive pile, in the air; within the cartridge two detonators are placed at a known distance apart, and into each is crimped one end of a detonating fuse, 1 yard in length; this fuse is bent so as to lie on a lead plate, 3 in. by 15 in., ¼ in. thick, which bears a mark; the cartridge having been fired by an electric detonator placed centrally in the cartridge, the distance between the mark and the point on the plate at which the detonations meet is measured. Impact, pressure, volume, gas evolution and heat determinations are made for suitability and for permissibility, partly in Trauzl lead blocks. In the large impact tests 20 grammes of the substance are spread in the form of a flat disc and confined between two steel discs, each ½ in. thick, within a Shelby steel tubing, 3·8 in. internal diameter; this is the confined test; in the unconfined test the charge and discs are placed on an anvil. Pendulum friction tests are conducted to determine the sensitiveness of the explosive to a glancing blow or to frictional impact. Whenever practicable storage tests are made for periods of 2, 4, 6 months. No charge is made to manufacturers for tests when minor changes are to be adopted in the preparation of the explosives; when the proposed change is considered a major one, the usual fees are charged to schedule.

QUICK LIFT SCARIFIER.

CONSTRUCTED BY MESSRS. MARSHALL, SONS AND CO., LIMITED, GAINSBOROUGH.



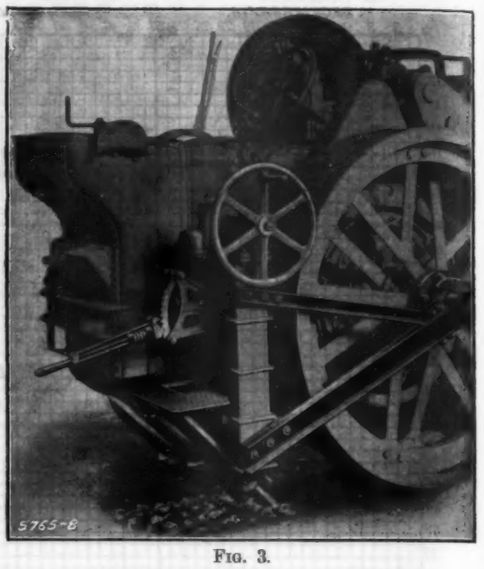


FIG. 3.

We illustrate above a new design of scarifier made by Messrs. Marshall, Sons and Co., Limited, of Gainsborough, the special feature of which is the arrangement for lifting the tines clear of the road to avoid such parts as manholes, paved crossings, &c. With the usual type of scarifier this operation frequently involves the stopping of the roller, and in any case necessitates a considerable degree of care on the part of the driver and attendant. With the scarifier we are now describing, however, the tines can be raised from or lowered into the road without stopping or slowing down the roller, by the movement of a single lever, thus saving both time and labour.

As will be seen from the illustrations, Figs. 1 and 2, the steel frame A is bolted to the tender of the roller and stayed by steel channels to the main axle. The tine holder B, which is also of cast steel, is provided with three slots in echelon, and in these the tines are secured by steel cotters. By means of the hand wheel C, at the side of the scarifier, the depth of cut can be adjusted, the movement being effected through the agency of a screw and bevel gear. The screw D (Fig. 1), however, is not directly connected to the tine holder, but to a toggle-joint mechanism comprising a bell-crank hand lever E and a link F. The fulcrum pin G is carried in a crosshead H formed at the end of the adjusting screw. This crosshead slides in a machined guide in the main frame, and carries notched quadrants J in which the ratchet catch-box of the hand lever engages. The link F connects the bell-crank lever with the tool holder by means of joint pins. By this means a quick lift of about 5 in. is obtained, and as the three joint pins are in a vertical line when the tool-box is in its working position, all reaction on the hand lever is prevented. Raising the lever thus raises the tines and *vice versa*. In the raised position the weight of the tool-box and tines is carried by strong helical springs, which are not shown in the illustrations as they are enclosed in spaces formed in the sides of the tool-box and suspended by bolts in the main frame. When the tines are lowered in the working position the whole of the thrust on them is taken by the toggle joint.

The photograph reproduced in Fig. 3 gives a good idea of the general appearance of the appliance.

GLAZES ON ZINC RETORTS.—When the fuel of zinc retorts is a coal rich in ash, and particularly in iron, a glaze may form on the retorts. The glaze is a complex silicate and is, on the whole, to be welcomed, according to O. Mühlhaeuser (*Metall und Erz*, November 8, 1918) because it prevents the flue gases from penetrating into the retort and the zinc vapours from exuding out of it. The glaze should be of high viscosity; if too fluid it may drop off and cause erosion. The formation of the glaze depends upon the flue dust, the retort surface and the position of the retort in the furnace. Mühlhaeuser analysed various glazes found on retorts and also on the partition walls of the furnaces. They are generally of a jet-black colour (owing to the presence of coal) or dark brown. When Mond gas is used as fuel, the conditions are not favourable for the formation of a glaze, because the flue dust is absent, and in such cases Mühlhaeuser thinks the artificial glazing of the retorts advisable.

THE GERMAN LABOUR PROBLEM.

THE labour problem in Germany is surrounded with increasing difficulties. Many industries are compelled to discharge hands in large numbers, thus swelling the ranks of the unemployed to an alarming extent, whilst men who are out of work seem indisposed to accept employment where this is obtainable. The Rhenish Metal and Machine Works, Düsseldorf, for example, a company which at the end of the war employed some 30,000 hands, do not see their way to arrange for reconstruction, and cannot find employment for the major part of their operatives. Under the most favourable conditions they might be able to find work for 7,000 hands. The reduction of their staff has commenced, mostly of artisans and others who had been engaged for war work, and who now are expected to return to their former occupations. There are also 11,000 female hands, for whom it is found a difficult matter to do anything. Special regulations have been drawn up for the discharge of female operatives, whereby they have been arranged in four classes, and are being discharged in the order of their classes. The first class comprises married women, whose husbands have work; the second class married and unmarried women, who have no one to provide for; the third class, married and unmarried women, who only have to provide for one or two persons; and the fourth class comprising all the other married and unmarried women. A similar grading applies to male labour; when a reduction of the hands becomes necessary, they are divided into three classes—unmarried who have no one to provide for; married men without children, and unmarried men who have to provide for relatives; and thirdly, all other male hands engaged during the war. Exceptional cases are specially considered.

The unemployment problem is causing very serious trouble and more serious apprehensions. In Munich, many thousands of returned soldiers wander about aimlessly, whilst labour entirely seems to ignore the large amount of work waiting at the big Walchernsee Power Station. The first day labour was advertised for at that station, 60 engineers and two workmen responded; the second day there were a couple of hundred engineers, but still only two men.

The unemployment insurance, as now arranged, has to face an unprecedented amount of unemployment, and the financial problem bids fair to become entirely ruinous, unless some compulsion to work can be brought about, but this does not appeal to the men. As a rule, the men particularly object to leaving the towns to seek employment in the country. A decree is being prepared, according to which unemployment assistance will be refused to persons who decline to undertake work for which they are suited. Labour is more especially needed in the coal and lignite mining industry, the production of both these fuels having receded very materially. In the Ruhr coal-mining district the production has now fallen to the same low level which obtained in the first months after the commencement of hostilities.

Fresh strikes keep breaking out within the coal industry, both in Silesia and Westphalia. In Silesia the men broke an agreement just entered upon, putting forth fresh demands and insisting upon an immediate answer; the employers refused, and in five of the leading mines work was stopped, the result being that the coal production in Upper Silesia has been reduced to one-half of the normal. The entire industry of Saxony is seriously threatened. The production of coal during the month of November was about 300,000 tons short, and for December the deficit was still larger.

THE DETERMINATION OF THE EFFICIENCY OF THE TURBO-ALTERNATOR.*

By S. F. BARCLAY, Ph.D., Associate Member, and S. P. SMITH, D.Sc., Associate Member.

SUMMARY.

WITH the methods ordinarily employed of establishing the efficiency of the turbo-alternator, the stray loss that is present on load is either deduced by a substantially conventional method or is ignored altogether. As alternators for larger outputs are constructed, the stray loss becomes of greater importance and, indeed, may prove to be one of the factors that will limit the maximum size of unit that it is desirable to employ. A still more unsatisfactory feature of the existing methods is that it is becoming impracticable to apply them to the very large alternators now being constructed, on account of the difficulty of providing a driving motor of sufficient power. Further, with a driving motor, it is obviously impracticable to make any tests on site. It becomes increasingly important, therefore, to introduce a method of establishing the alternator efficiency which is based on the measurement of the actual losses on load.

The object of this paper is to show that the actual losses on load can be deduced conveniently and accurately from measurements of the cooling air flowing through the alternator. It is further shown, however, that although such methods are sound in principle, misleading results may be obtained unless certain precautions are taken in applying them.

INTRODUCTION.

The efficiency of a turbo-alternator is usually expressed in terms of the rate of steam consumption in relation to the output of electrical energy, and therefore the purchaser has little direct economic interest in the accurate determination of the efficiency of the alternator. Nevertheless the matter is of considerable interest to the purchaser, since the efficiency of the alternator is an indication of the quality of the active materials employed and of the degree of excellence of the design. The manufacturer is more vitally concerned in the matter, for the reason that the accurate determination of the alternator efficiency is the only means of ascertaining the magnitude of the actual stray loss; for if the total loss on load can be found, the stray loss can be deduced when the other losses have been measured separately. With turbo-alternators of even moderate size the stray loss may be as high as five or six times the ohmic loss in the stator copper and, in the opinion of some authorities, this loss may prove to be one of the factors that will limit the output of electrical energy obtainable from a single unit. It will be seen, therefore, that if the efficiency on load can be determined accurately it will be one of the most important of the designer's informative tests.

The common practice in this country is to base the guarantees of the alternator efficiency on the summation of the various losses that can be measured separately and either to ignore the stray loss altogether or to employ a substantially conventional method of determining it. Thus, some makers measure the windage and friction and the stator core loss (*e.g.*, by driving the alternator with a calibrated motor) and calculate the copper losses (*e.g.*, by deducing the full load exciting current from open-circuit and short-circuit tests and taking the stator copper loss equal to the ohmic loss

* Paper read before the Institution of Electrical Engineers on February 27.

as for a direct current). The sum of the separate losses thus obtained is then assumed to represent the total losses in the alternator. The efficiency obtained in this way, however, is practically meaningless since the stray loss is entirely ignored. Other manufacturers make an allowance for the stray loss by assuming that it bears some definite relation to the stray loss present when the machine is run on short circuit. In the conventional method adopted by the American Institute of Electrical Engineers, and used by some manufacturers in this country, the whole of the stray loss present on short circuit is included when computing the conventional efficiency of polyphase machines (see Appendix II, Rule 458). That the nature and distribution of the loss under the two conditions may be quite different, however, is shown by studying the heating in the two cases. When making short-circuit tests the authors have found in some cases great heating of the laminations at the ends of the stator core and considerable, although somewhat less, heating of the stator end plates, whereas on full load the temperature of those parts was quite normal. For instance, in the case of a 5,000-kw. alternator at 3,000 r.p.m., embedded thermocouples showed a temperature rise of 250 deg. F. at the ends of the stator core after running for an hour on short circuit, although on full load the temperature rise of the same parts was only 60 deg. F. This phenomenon has not been fully investigated by the authors, but it is possibly due in part to a reverse flux between the stator core and the rotor steel end-bells which can only exist under short-circuit conditions. It will be seen, therefore, that when there is agreement between the value of the stray loss on load and on short-circuit it is partly accidental and is not to be expected in all cases. The investigations carried out by the authors confirm this reasoning, for although there is fairly close agreement between the two values in some cases, there is considerable disagreement in others, as is shown by the typical test results given in Table VII.

The efficiency can also be determined by running the alternator as an over-excited synchronous motor, but the kilovolt-amperes that have to be circulated limit the size of machine that can be dealt with in this way. Further, although the test can be made with full flux, a current lagging almost 90 deg. F. behind the electromotive force may give a value for the stray loss that is different from the actual loss on load. Also, the rotor copper loss with such a test is invariably too high, and to make the necessary correction entails a knowledge of the proper exciting current.

When two similar machines are available the Hopkinson test can be used, but the application of such a test to turbo-alternators is obviously very limited and is now rarely used.

It will be seen that at present there is not in common use any accurate method of determining the efficiency of the turbo-alternator, nor is there any standardised conventional method whatever in use in this country. It is an obvious and increasing necessity that a standardised method of establishing the efficiency should be adopted and, if possible, the method should not be one in which conventional values are assigned to one or more of the losses. Further, the method should preferably be one that can be applied at any time after the alternator has been erected on site.

For some time past the authors have been investigating the subject in conjunction with turbo-alternators made at the Sheffield works of Messrs. Vickers, Limited, and their investigations show that provided certain precautions are taken, the alternator efficiency can be conveniently and accurately determined under actual load conditions from measurements of the cooling air. From such measurements the separate losses can also be deduced—a matter of considerable importance when a driving motor is not available.

Determination of the Loss in Turbo-Alternators on Load from Measurements of the Cooling Air.

Modern turbo-alternators invariably have forced ventilation, and with the exception of the relatively small amount of heat dissipated from the external surface of the stator all the losses, except the bearing losses, are carried off by the cooling air. Consequently the most obvious method of finding the losses on load is to ascertain, with regard to time, the heat energy that is being carried away by the ventilating air; for if the volume of air flowing through the machine in unit time, and the average increase of temperature that the air undergoes in absorbing the losses in the machine, are known, then the total losses on load can be calculated without difficulty. This method will hereinafter be referred to as the "air-heating" method. The principle involved in this method formed the subject of a paper on "The Testing of Electric Generators by Air Calorimetry," read before the Institution* in 1903 by Professor R. Threlfall, the machines in this case being totally enclosed in a specially constructed housing.

An alternative method that does not involve measuring the air volume is to ascertain the increase in temperature of the cooling air caused by a loss of known magnitude in the alternator, and from the observed temperature rise of the air on load to deduce the total losses. This method will hereinafter be referred to as the "calibrated air-temperature"-method.

In the determination of the losses in the alternator from the cooling air, the bearing losses are not included. Such an arrangement is not altogether illogical, since, when the turbine builder sublets the contract for the alternator, it is the custom for him to supply the alternator bearings and it is a simple matter for him to make the allowance for the bearing losses. These losses may be determined fairly accurately by measuring the volume and temperature rise of the lubricating oil and by making a suitable allowance for the heat dissipated in other ways. Since the bearing losses constitute but a small percentage of the whole, a fairly big error in determining them would have only a small effect on the result.

* Journal I.E.E., 1904, vol. xxxiii, page 28.

Measurement of Air Volume and Temperature.

Air velocity can be measured in a variety of ways, and any of the following methods could be considered for our present purpose:—

(1) The Pitot tube.
(2) The Venturi tube.
(3) Electrical methods.
(4) The anemometer.

(1) *Pitot Tube.*—The Pitot tube consists essentially of a dynamic tube placed in the line of air flow and a static tube with the plane of its orifice set at right angles to the line of air flow. The shape and size of the orifice of the dynamic tube have been found by careful experiment to be unimportant, but the size and position of the orifice of the static tube are most important.* Tubes conveying the two pressures, *i.e.*, the dynamic and static heads, are connected to a differential fluid gauge. The difference of pressure that the gauge shows has been found to be proportional to the square of the air velocity over a very wide range. For the present purpose the average gauge readings are of the order of one-fifth of an inch of water, and for accurate work with such low pressures it is necessary to employ a special form of manometer with the tube inclined at a large angle to the vertical. The micro-manometer designed by Mr. B. J. B. Roberts† is very exact and has been employed by the authors in their investigations with excellent results. Another very accurate type of manometer is a tilting tube operated with a micrometer screw that is adjusted until the index bubble assumes the central position and the difference of dynamic and static pressures is given by the micrometer reading.‡ Such instruments are hardly suitable for the present purpose, on account of the skill required in using them and the time required to take the readings. For example, Sir J. I. Thornycroft found that with the Roberts' micro-manometer it may take 5 minutes or more for the index bubble to reach its final position.

* Journal of the American Society of Mechanical Engineers, 1912, vol. xxxiv, page 1341.

† Proceedings of the Royal Society, 1906, vol. lxxviiiA, page 410.

‡ ENGINEERING, 1912, vol. xciv, page 892, and *ibid.*, 1913, vol. xcvi, page 343.

§ J. T. Morris, British Association, Section G, Dundee, 1912—see ENGINEERING, 1912, vol. xciv, page 892.

‖ Transactions of the American Institute of Electrical Engineers, 1909, vol. xxviii, page 363.

The principal objection to the Pitot tube, however, for this work is that when making absolute measurements it is dependent for its accuracy on the air flow being in line with the dynamic tube and at right angles to the static tube—conditions that cannot exist when the air flow is variable in direction. To facilitate the accurate measurement of the velocity of the air leaving the alternator it is desirable to fit a temporary discharge trunk, as described below; but no matter what precautions of this kind be taken there is still some appreciable variation of the air velocity from point to point over the discharge outlet, indicating a non-streamline flow. With the air flow varying in direction from point to point in this way any particular Pitot tube reading may not give accurately the average velocity at that part.

(2) *Venturi Tube.*—The Venturi tube is a very exact instrument, but for its accuracy it is even more dependent than the Pitot tube on the flow of air being constant in direction and it is therefore unsuitable for the present purpose.

(3) *Electrical Methods.*—The electrical measurement of air velocity, based on the law that an electrically-heated wire in a current of air cools at a rate that is dependent on the velocity of the air current, has been successfully carried out.§ A wire of high electrical resistance-temperature coefficient, such as platinum, is employed, and either a constant voltage is maintained across it and the variation in resistance read, or the resistance is maintained at a constant value and the necessary variations of current are read. The air velocity is deduced from the readings on the basis of the law discovered by Dr. Kennelly and Messrs. Wright and Van Bylebelt,‖ that with unvarying wind velocity the linear forced convection of a thin wire increases as the square root of the air velocity. A hot-wire velocity indicator operating on this principle has recently been devised by Professor J. T. MacGregor-Morris, who kindly provided facilities for the authors to inspect the instrument. Four exactly similar wires of material having a high electrical resistance temperature coefficient are arranged as a Wheatstone bridge. One pair of opposite arms of the bridge is exposed directly to the air current; the other pair is also in the air current, but is protected by being enclosed in thin-walled tubes of high thermal conductivity. This small bridge is attached to the end of a tube of convenient length and the leads are carried inside the tube to a portable battery and to a milliammeter or millivoltmeter. The difference between the cooling of the arms of the bridge that are exposed to the air current and the arms that are shielded from it is indicated on the ammeter or voltmeter, which can be calibrated to read the air velocity directly. The indicator attains a steady reading in a few seconds and in the form described it is suitable for measuring velocities up to about 2,000 ft. per minute. Such an instrument should be satisfactory for measuring the air discharge from a turbo-alternator, particularly since the accuracy would be little affected by the air having a non-streamline flow, as must be the case to some extent. The authors have already made arrangements for testing the suitability of the instrument for the class of work in question.

(4) *Anemometer.*—The anemometer is usually considered to be somewhat inaccurate, but for the purpose in view the authors have found that a well-made instrument when properly handled gave sufficiently accurate results. Further, on account of the air flow being variable in direction, the anemometer is probably better adapted to read the absolute value of the average velocity at a given point than are more exact instruments.

The two inherent defects of the anemometer are the effects of the friction and the inertia of the moving parts. The effect of friction on the reading is, however, slight when the velocity of the air is considerable. The velocity of the air discharge from a turbo-alternator is of the order of 2,000 ft. per minute and, with an instrument of the kind used by the authors measuring about 2·6 in. over the tips of the vanes, the frictional effect is not more than 3 per cent. of the vane wheel speed so that even an appreciable error in the correction for friction has only a negligible effect on the result. The other inherent defect of the anemometer—the effect of inertia—is only of appreciable importance when the air flow is variable. When a jet of air is directed on to the vanes there is a little delay before the vane wheel assumes the velocity corresponding to the air velocity; and on the other hand when the jet of air is removed the vane wheel continues to rotate for some time. The retardation period is decidedly longer than the acceleration period, with the result that when measuring a variable air velocity the anemometer tends to give too high a reading. This defect is of negligible importance for the object in view, since the air velocity does not vary at any given point.

The authors have checked the accuracy and consistency of the anemometer in several ways. When a fan delivers air to a given system of ducts, the volume of air discharged is a linear function of the speed of the fan*—that is, if V is the volume of air delivered in unit time, and n is the speed of revolution of the fan, then $V = K n$, where K is a constant. Therefore by running an alternator at various speeds and measuring the air volume in each case, the accuracy of the anemometer readings is established if they bear a constant ratio to the speed of rotation. The authors have found that the results obtained in this way are very satisfactory, as is shown in the typical case given in Table I.

The accuracy of the anemometer readings was further checked by comparing a known loss in the alternator with the heat energy being carried away by the air. Such a proof is dependent on the accurate measurement of the average air temperature, and in order to reduce possible error of this kind to a negligible extent, a large number of thermometers was employed. Typical results of such tests are given in Table II, and the close agreement between the last columns will be noted.

In order to verify the consistency of the anemometer readings, two new instruments, calibrated at the National Physical Laboratory, and an instrument that had been in use for two years were mounted in succession in a given position at the discharge outlet of an alternator and were run for varying periods, during which the speed of the alternator and the load were maintained as constant as possible. The satisfactory results obtained are shown in Table III. The instruments are necessarily

* ENGINEERING, 1915, vol. xcix, page 617.

TABLE I.—*Machine No.* 7,634.

V	4,550	7,200	8,950	10,900
n	1,500	2,400	3,000	3,600
K	3·033	3·000	2·983	3·028
Variation from mean value of K	per cent. +0·73	per cent. −0·87	per cent. −0·93	per cent. +0·56

TABLE II.

Machine No.	Rotor Unexcited.				Rotor Excited.				Stator Core Loss + Excitation] Loss in Kw.	
	V.	T_f.	T_o.	P_u.*	V.	T_f.	T_o.	P_e.*	Calculated ($P_e - P_u$).	Measured by Driving Motor.
7,541	3,160	61·7	76·0	14·4	3,290	64·0	113·7	48·8	34·4	34·6
7,729	5,220	64·0	75·0	18·3	5,400	64·0	103·0	64·3	46·0	45·5
7,325	14,400	73·0	87·0	63·3	14,800	87·5	123·0	154·5	91·2	92·0

* P_u and P_e represent the losses heating the cooling air when the alternator is run unexcited and excited respectively, and are calculated from equation (2) below.

TABLE III.

—	Calibrated Anemometer, No. 1.	Calibrated Anemometer, No. 2.	Test Anemometer (after Two Years' use)
Running for 1 minute—			
Dial reading	1,316	1,296	1,325
Air velocity	1,316	1,296	1,325
Variation from mean ..	0·28 p.c.	1·24 p.c.	0·97 p.c.
Running for 5 minutes—			
Dial reading	6,393	6,517	6,649
Air velocity	1,318	1,304	1,329
Variation from mean ..	0·08 p.c.	0·99 p.c.	0·91 p.c.
Running for 15 minutes—			
Dial reading	19,804	19,504	20,020
Air velocity	1,320	1,300	1,335
Variation from mean ..	0·15 p.c.	1·37 p.c.	1·29 p.c.
Running for 60 minutes—			
Dial reading	79,563	79,027	80,469
Air velocity	1,326	1,317	1,341
Variation from mean ..	0·15 p.c.	0·83 p.c.	0·98 p.c.

delicate in construction and liable to damage by rough handling, so it is desirable that the accuracy should be tested in some such manner from time to time.

The anemometers used by the authors were supplied by Messrs. Negretti and Zambra and are of the type illustrated in Fig. 11, on page 295. The makers guarantee the instruments not to vary more than 1 per cent. over the range of air velocity for which they are suitable.

Determination of Average Velocity of Air.—The first difficulty that the authors encountered in the measurement of the volume and temperature of the air was a consequence of the great variation in the velocity of the air at the discharge opening of the alternator, due to the essentially peculiar shape and disposition of the openings in the stator core and frame, and also of the rotation of the rotor tending to cause the air to discharge obliquely instead of vertically.

In order to investigate the nature of the air flow, a Pitot tube was mounted on suitable gear and was slowly traversed across the discharge opening. The type of Pitot tube used is shown in Fig. 2, and the manometer used in conjunction with it was of the Roberts pattern with xylol for a fluid (specific gravity, 0·856). Before taking each reading the inclination of the Pitot tube was varied until a maximum displacement in the manometer was obtained. By taking readings in this way at frequent intervals, the variation in the direction and velocity of the air over the discharge opening was ascertained fairly accurately. It was found that the air was eddying violently and that there was actually a reverse flow in some places. With such a variable air flow, the accurate measurement of the volume and average temperature is a matter of the greatest difficulty and most probably the results obtained under such conditions would be quite misleading. With the object of equalising the air flow a temporary discharge trunk of the kind shown in Fig. 3 was fitted, and the air velocity was again measured by traversing the Pitot tube across the discharge opening. The improved result obtained with the trunk is shown by curve B in Fig. 4. To equalise further the air velocity, close-mesh expanded-metal baffle plates were fitted in the trunk as shown in Fig. 3, and the improvement obtained is shown by curve A in Fig. 4. It will be seen that although there is still some variation, yet if the anemometer readings are taken at fairly frequent intervals the average velocity can be found with a sufficient degree of accuracy. The resistance of the expanded metal baffles to the flow of air was found to have no appreciable effect on the temperature of the alternator. Of course, if there were any effect of this kind it would not affect the accuracy of the determination of the losses in the alternator, for any restriction to the flow of air would only cause a corresponding increase in temperature; but the matter would be important in so far as the efficiency could not be measured during the heating test—which is desirable from the point of view of saving time, and also, if running on an artificial load, expense.

For the accurate measurement of the air volume it is desirable that the discharge opening should be divided into squares, not much larger than the overall diameter of the anemometer, by stretching thin cords across the trunk as is shown in Fig. 3, and an anemometer reading should be taken over each square. For small and medium-size machines the squares could conveniently be made with a length of side of 4 in., but for very large machines the size might be increased somewhat to avoid taking an unnecessarily large number of readings. A certain error is introduced into the readings by the delay in starting and stopping the anemometer, and also as a consequence of the manipulation of the catch that throws the recording dials in and out of gear, interfering locally with the air flow. These difficulties can readily be overcome by moving the instrument rapidly from square to square without stopping it, and the average value of the air velocity is found by dividing the total reading by the number of squares. The authors have found a slight but appreciable effect in adopting this safeguard. It is desirable to run the anemometer for an appreciable period over each square—15 seconds being the minimum desirable time and a longer period up to 1 minute being preferable when circumstances permit.

Determination of Average Temperature of Air.—The average temperature of the air can be found with sufficient accuracy by using one thermometer for each square and taking the average of the readings. The thermometers can conveniently be attached to the cords in a horizontal position. The authors have tried the experiment of using several thermometers in each square, but they find that the result is not appreciably different from that obtained by using one for each square. The determination of the average temperature of the inlet air presents no difficulty, but it should be verified that there is no external source of heat, such as a steam pipe, near the thermometers. When an air filter is used in conjunction with the alternator, the inlet temperature has to be read between the filter and the alternator, and it is particularly necessary to do so when the filter is of the wet type.

The average temperature of the air at the inlets and outlets can also be determined very accurately by measuring the change in resistance of a coil of wire, of which the electrical resistance-temperature coefficent is known, mounted in the air flow. The authors have found very close agreement between the results obtained in this way and those obtained by thermometer measurement, but for general work the thermometer is obviously more convenient.

It is not infrequently the custom with large alternators to discharge the ventilating air from the bottom of the stator and lead it away in ducts from the engine-room. In such cases it is quite convenient to provide a discharge opening at the top of the alternator that can be used for making the air-volume and air-temperature measurements. Whilst the tests are being made the lower discharge opening is temporarily closed, and for normal running the upper opening is closed with a plate. By standardising the size of discharge opening only a few temporary discharge trunks are necessary for a wide range of sizes of alternators.

It will be seen that the precautions to be taken in the measurement of the air volume and temperature are simple, but without such precautions the authors have found that quite misleading results may be obtained.

Fig. 2.

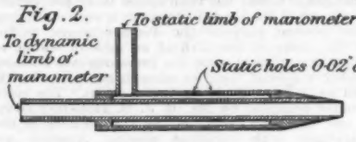


FIG. 2.—Pitot tube.

Fig. 3.

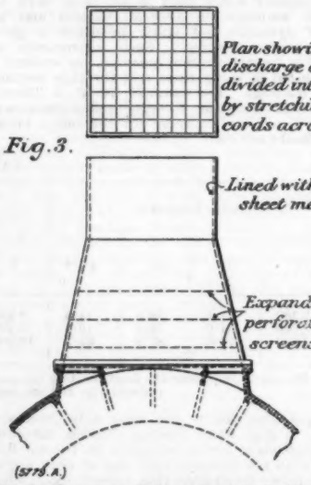

Plan showing discharge opening divided into squares by stretching thin cords across.
Lined with thin sheet metal.
Expanded or perforated metal screens.
(5775 A.)

FIG. 3.—Temporary discharge trunk to facilitate the accurate measurement of the air volume and temperature.

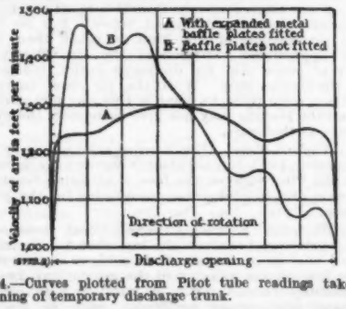


FIG. 4.—Curves plotted from Pitot tube readings taken at opening of temporary discharge trunk.

METHOD 1.

THE DETERMINATION OF THE LOSSES ON LOAD BY THE "AIR-HEATING" METHOD.

Having seen that it is quite practicable to measure the volume and temperature rise of the air with sufficient accuracy, the method of calculating the losses from the volume and temperature rise of the air will now be described. In making the following calculations the value of 0·0711 lb. is taken for the weight of a cubic foot and 0·242 for the specific heat of dry air at the assumed temperature of 100 deg. F. and at an atmospheric pressure equal to 29·92 in. of mercury. The mechanical equivalent of heat is taken to be 778 ft.-lb. per therm.

Let V = volume of air leaving the alternator discharge in cubic feet per minute.
T_i = average temperature of the air at the inlets.
T_0 = average temperature of the air at the alternator discharge.

The heat energy being carried away by the air is then:

$$P = V \times 0{\cdot}0711 \times 0{\cdot}242 \times (T_0 - T_i) \times 778 \text{ ft.-lb. per minute,}$$

$$= \frac{V \times 0{\cdot}0711 \times 0{\cdot}242 \times (T_0 - T_i) \times 778 \times 746}{33{,}000 \times 1{,}000} \text{ kw.,}$$

$$= \frac{V\,(T_0 - T_i)}{3{,}305} \text{ kw.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where T_i and T_0 are in degrees Fahrenheit.

The various corrections that may have to be made to the above formula are dealt with in Appendix I. It is there shown that, for commercial testing, corrections need be made only in the event of the air temperature or barometric pressure differing appreciably from the conditions assumed and in respect of the heat energy that is dissipated from the stator frame. The correction curves given in the appendix may be used with formula (1) or this formula may be amended to include the corrections as follows:—

$$P = \frac{V\,(T_0 - T_i)}{3{,}305} \times \frac{H}{29{\cdot}92} \times \frac{460 + 100}{460 + T_0} \times \frac{100}{98{\cdot}5},$$

$$= \frac{V\,H\,(T_0 - T_i)}{174\,(460 + T_0)} \text{ kilowatts} \quad . \quad . \quad (2)$$

where T_i and T_0 are in degrees Fahrenheit.

If T_0 and T_i are in degrees Centigrade:

$$P = \frac{V\,H\,(T_0 - T_i)}{174\,(273 + T_0)} \text{ kw.} \quad . \quad . \quad (2A)$$

METHOD 2.

THE DETERMINATION OF THE LOSSES ON LOAD BY THE "CALIBRATED AIR-TEMPERATURE" METHOD.

Various methods have been suggested for calibrating the temperature rise of the air in terms of the loss in the alternator. The following method was adopted by the authors as being convenient and independent of the use of any quantities that cannot be measured directly.

When the alternator coupled to a driving motor is being run at the works, the stator core loss with various values of the exciting current can be measured—a test that it is always desirable for the maker to carry out for his own information. When the machine is being tested on site, the temperature rise of the cooling air is measured (1) on open circuit with the rotor unexcited, (2) on open circuit with the rotor excited to a known value, (3) with the alternator on load.

Let t_e denote the temperature rise of the cooling air in test (2) with the rotor excited, P_e the rotor copper loss, and P_i the stator core loss corresponding to this excitation (the value P_i is given by the core-loss curve taken at the works). Then, if t_u denotes the temperature rise of the cooling air in test (1) with the rotor unexcited, it follows that the difference $t_e - t_u$ in the rise in temperature of the cooling air is caused by the known loss $P_i + P_e$ kw. The loss in the alternator necessary to cause the temperature of the ventilating air to increase 1 deg. is then:

$$\Delta P = \frac{P_i + P_e}{t_e - t_u} \text{ kilowatts.}$$

The quantity ΔP thus represents the calibration of the temperature rise of the cooling air of the machine in question.

If now t_l denotes the temperature rise of the cooling air in test (3) when the alternator is on load, it follows that the load loss will be:

$$P = \frac{P + P_e}{t_e - t_u}\, t_l = \Delta P \times t_l \text{ kilowatts.} \quad (3)$$

The formula holds good, of course, for either the Fahrenheit or the Centigrade thermometer.

The accuracy of the "calibrated air-temperature" method depends mainly upon the weight of air flowing through the machine remaining constant whilst the heating tests are being made. The effect of losses in the alternator is of course to heat the air and cause it to expand and so increase the volume for a given weight. The opposition to the flow of an increased volume of air will depend on the position of the part where there is the greatest restriction to the airflow with respect to the position of the parts where the heating occurs. For instance, with a radially-ventilated stator the resistance encountered by the air passing from the fan chambers to the gap and from the gap to the radial ducts constitutes the principal restriction to the air flow; consequently, additional heating in the stator core would affect the weight of air flowing through the machine very little, whereas additional heating in the fan chambers and rotor would have appreciable effect. With large machines it may be found that the calibration loss cannot conveniently be made greater than about one-half the total load losses even when running considerably over-excited. On load, the loss in the body of the core will be considerably less than during an over-excited calibration test and the greater loss will be in the rotor, the stator copper, and the stator teeth. This alteration in the distribution of the loss and the greater magnitude of it will cause the air to increase in temperature and expand before it enters the stator ducts, and so the volume of air flowing through the machine cannot increase in quite the same proportion as the increase of the absolute temperature of the air—

as must be the case for the air weight to remain constant. The effect of this reduction in the weight of air flowing through the machine under load is to make the calibration figure ΔP slightly high with respect to actual load conditions, or, alternatively, the temperature rise t_l on load slightly high with respect to the calibration conditions; in consequence of which the load losses given by this method are somewhat too large. The extreme magnitude that it would be possible for this error to have would exist if the air volume on load were the same as during the calibration test; in this case the reduction in the weight of air would cause an error of about 4·4 per cent. (this figure is arrived at on the assumed probable conditions of the air entering at 45 deg. F., the windage loss causing a rise of 15 deg. F., the calibration loss a rise of 25 deg. F., and the load loss a rise of 50 deg. F.). The actual error, however, will be less than 4·4 per cent., since all the additional air-heating on load, compared with the heating during calibration, does not take place before the air flows through the points of restriction, and the authors have estimated that even in radially-ventilated machines the losses given by this method are only 2 per cent. to 3 per cent. too high. This estimate is confirmed by tests (*cf.* Table VI). A general correction cannot be made in respect of this error, since it will be influenced by the system of ventilation apart from the different distribution and magnitude of the losses during calibration and on load. Also, for the latter reason, the slight error due to the difference in the dissipation of heat from the stator under the two conditions cannot be corrected by a constant multiplier, as is possible with the "air-heating" method. In the absence of accurate information it can be assumed that due to these causes the losses obtained by the "calibrated air-temperature" method are 2½ per cent. too high.

TESTS.

Typical results obtained by the "air-heating" and "calibrated air-temperature" methods are given in Tables IV and V. A comparison of the losses so obtained

TABLE IV.—*Determination of Load-Loss by the "Air-Heating" Method.*

Machine No.	Air Volume in Cub. Ft. per Min.	Air Temperature in Deg. F. at		Load loss in Kw. (from Equation 2)
		Inlet T_i	Outlet T_o	
5,862	16,800	45·0	116·6	352
7,001	21,330	53·0	103·9	327
7,541	3,300	66·2	114·0	46

with the "summation of losses" method as adopted by the American Institute of Electrical Engineers, and with this method when an allowance for stray loss is excluded, is given in Table VI.

GENERAL CONCLUSIONS.

"Air-Heating" Method.—These investigations have led the authors to the opinion that the "air-heating" method may quite well be adopted for the determination of the turbo-alternator efficiency for commercial purposes, with advantage to the purchaser and the manufacturer. By taking the prescribed precautions when measuring the air volume and temperature, the losses on load can be determined quite as accurately as is required and probably more accurately than in any other way. From the manufacturer's point of view a great advantage of the method is that a driving motor is not required—an item of importance when dealing with alternators of large output. Also, when on account of transportation difficulties the stator has to be built on site, in addition to measuring the total losses on load the method could also be employed to measure the separate losses with ease and accuracy.

The method is independent of tests made at the works, and in the event of dispute a check test could be made at any time. The ease with which the test is applied would enable periodic readings of the losses to be taken, and useful information concerning the variation of efficiency (if any) with age could be obtained. Moreover, the measurement of the air volume that would be involved would be of value in indicating accurately if any restriction to the air flow was arising due either to the ducts in the alternator becoming choked with foreign matter or to increased resistance in the filter.

"Calibrated Air-Temperature" Method.—This method has the one advantage compared with the "air-heating method that the air volume has not to be measured, but on the other hand it has certain disadvantages. The efficiency cannot be determined solely by tests on site, and once the alternator has been despatched from the works, a check test in the case of dispute cannot be made.

In addition to any error due to the weight of air flowing through the machine being somewhat less on load than during calibration as already discussed, a further possible cause of error is in the determination of the stator core loss, on which the result is based. It is usually necessary to employ reduction gearing or a belt drive between the driving motor and the alternator, and in such cases there is uncertainty as to the transmission losses. The authors have had the opportunity of comparing the losses in two sets of modern double-helical gears when transmitting power and they found an appreciable difference between the results. The loss with a belt drive when transmitting power at a high speed is liable to vary and is difficult to determine accurately.

When a driving motor is not available, as may be

TABLE V.—DETERMINATION OF LOAD LOSS BY "CALIBRATED AIR-TEMPERATURE" METHOD.

Machine No.	Known Loss $P_i + P_r$	Air Temperature Rise with Rotor.		Air Rise due to $P_i + P_r$:— $t_e - t_u$	$\Delta P = \frac{P_i + P_r}{t_e - t_u}$	Air Rise on Load t_l	Load Loss (from Equation 3) $\Delta P\, t_l$
		Unexcited t_u	Excited t_e				
5,862	167·5	15·1	48·3	33·2	5·05	71·6	362
7,001	195·5	20·4	51·2	30·8	6·35	53·4	338
7,541	34·6	14·3	40·6	25·3	0·98	47·8	47

TABLE VI.—*Comparison of Results obtained by Four Different Methods.*

Machine No.	Methods Based on Cooling Air.		Methods Based on "Summation of Losses."	
	"Air-heating" Method.	"Calibrated Air-temperature" Method.	A.I.E.E. Method.	Stray Loss Ignored.
5,862	352	362	336·0	211·0
7,001	327	338	315·0	255·0
7,541	46	47	52·5	42·8

TABLE VII.—*Comparison of Stray Loss on Load with Stray Loss on Short Circuit.*

Machine No.	Stray Loss on Load (determined by "Air-Heating" Method).	Stray Loss on Short Circuit (as determined in A.I.E.E. Conventional Method).
5,862	141·0	125·0
7,001	72·0	60·0
7,541	3·2	9·7

the case with large machines, or when the stator has to be built on site, the core loss can be ascertained by the application of some such method as the sudden cutting off of the steam supply and measuring the difference in retardation caused by the core loss. From these measurements and a calculation of the inertia of the revolving mass the core loss can be deduced. Apart, however, from the difficulty of ascertaining the losses in this way, an accurate result is not to be expected therefrom.

Existing Methods.—The "summation of losses" methods in present use, which ignore the stray loss have little value except that in the absence of any standardised logical method they serve to prevent disputes between the contracting parties when the turbine builder sub-lets the contract for the alternator. With regard to the special form of the "summation of losses" method put forward by the American Institute of Electrical Engineers, it has already been noted that the total losses obtained in this way may not in some cases differ sufficiently from the true loss to affect seriously the value of the efficiency deduced therefrom (*cf.* Table VI); but the conventional allowance made for the stray loss may differ appreciably from the actual value (*cf.* Table VII). Apart from the inaccuracy of these methods in principle, there is the possibility of error in measuring the various losses. Thus, to ascertain the excitation loss, the exciting current has to be calculated, *e.g.*, from the open-circuit and short-circuit curves. Reference has already been made to the possible inaccuracies in measuring the core loss with a driving motor, and still more so when a driving motor is not available.

An extract from the Rules of the American Institute of Electrical Engineers relevant to the determination of turbo-alternator efficiency is given in Appendix II.

It is unnecessary to deal with the various unsatisfactory methods of determining efficiency that are in use, with which dependence in a lesser or greater degree is placed on guesswork.

In conclusion, the authors beg to express their obligation to Mr. Douglas Vickers and Mr. W. Clark, directors of Messrs. Vickers, Limited, for permission to carry out the experimental investigations referred to in this paper and to publish the results; also to Mr. H. P. Hayhurst and his testing staff for the care that they have taken in carrying out the tests.

APPENDIX I.

CORRECTIONS FOR "AIR-HEATING" METHOD.

Correction 1. *Effect of Temperature on Air Density.*—At a given atmospheric pressure, the weight per cubic foot of air varies in inverse proportion to the absolute temperature. In making the calculations given in formula (1) the temperature of the air at the discharge is assumed to be 100 deg. F., and a cubic foot of dry air at that temperature with the standard atmospheric pressure weighs 0·0711 lb. per cubic foot. The actual weight of air passing through the machine per minute when the outlet temperature is T° deg. F. is given by:

$$\frac{(460 + 100)}{(460 + T_0)} \times 0{\cdot}0711 \times V \text{ lb.}$$

This expression is for dry air and standard barometer.

If the air temperature should differ appreciably from the value assumed, as it may, an important error would arise, as will be seen from the curve given in Fig. 5. The formulæ in their final form, (2) and (2A), have the correction included, but if formula (1) is used then the necessary correction is to be read from the curve, corresponding to the temperature of the outlet air.

Correction 2. *Effect of Atmospheric Pressure on Air Density.*—For a given temperature, the weight of air is directly proportional to the atmospheric pressure. In this country the barometer at the sea level seldom reads higher than 30·5 in. and seldom lower than 28·5 in., but a pressure as low as 27·332 in. has been recorded in Scotland, and as high as 31·62 in. in Siberia."*

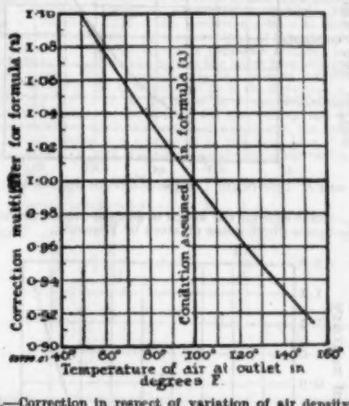


FIG. 5.—Correction in respect of variation of air density with temperature for use with formula (1). (This correction is allowed for in formulæ (2) and (2A).)

Allowing for some power stations being at a considerable height above sea-level, an appreciable variation from the standard barometric pressure 29·92 in. may well be experienced. The weight of air per minute passing through the machine, if dry, and at the temperature of 100 deg. F., is found from the expression:

$$\frac{H}{29{\cdot}92} \times 0{\cdot}0711 \times V \text{ lb.},$$

where H denotes the atmospheric pressure in inches of mercury. The formulæ in their final form, (2) and (2A), have the correction included, but if formula (1) is used, then the necessary correction is to be read from the curve given in Fig. 6 corresponding to the barometer reading at the time the test is made.

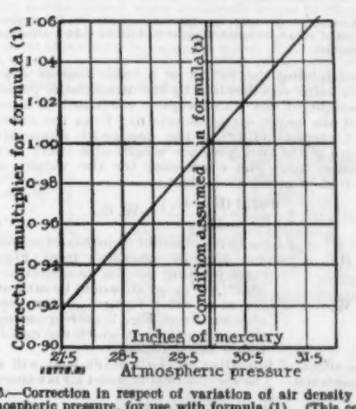


FIG. 6.—Correction in respect of variation of air density with atmospheric pressure, for use with formula (1). (This correction is allowed for in formulæ (2) and (2A).)

Correction 3. *Effect of Humidity on Air Density and Specific Heat.*—At a given pressure and temperature, the weight of a cubic foot of air varies a little according to the degree of humidity, in consequence of water vapour being lighter than air. On the other hand water vapour has a higher specific heat than air, hence the effect on humidity is to increase slightly the specific heat of the air, so that in considering the correction the combined effect has to be ascertained.

The effect of humidity on the air density will be dealt with first. The density of water vapour varies considerably with the temperature, as is shown in Fig. 7. The pressure of water vapour at different

* F. W. Henkel, "Weather Science," page 65.

temperatures is shown in Fig. 8. From these curves the weight of unsaturated moist air at a given temperature and pressure can be calculated. From Dalton's Law of Partial Pressures, it is known that the total pressure exerted by a mixture of two gases in a vessel is equal to the sum of the pressures that would be exerted if each filled the vessel alone. The temperature at which the air would be saturated, i.e., the dew-point, having been ascertained, the pressure of the aqueous vapour is found from Fig. 8. This pressure is deducted from the atmospheric pressure, and the weight of dry air contained in a cubic foot of the moist air is found

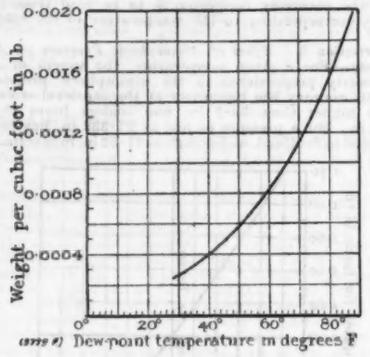


FIG. 7.—Curve showing the weight of aqueous vapour at various temperatures (from values obtained by Regnault).

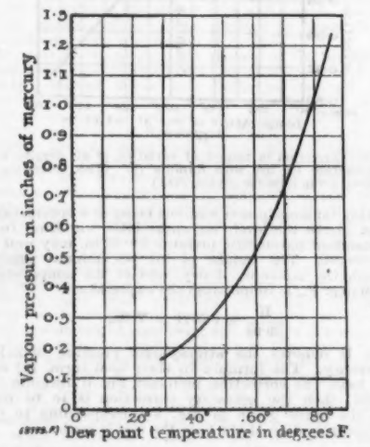


FIG. 8.—Curve showing the pressure of the water vapour in saturated air at various temperatures (from values obtained by Regnault).

by multiplying the weight of a cubic foot of dry air by this value and dividing by the atmospheric pressure. The weight of the water vapour contained in a cubic foot of the moist air is ascertained from the curve in Fig. 7 corresponding to the dew-point temperature. The sum of the two gives the weight of a cubic foot of the moist air. The expression for the weight of a cubic foot of moist air is then :

$$\frac{0{\cdot}0711\,(H - H_v)}{H} + W_v \text{ lb.},$$

where H = atmospheric pressure in inches of mercury.
H_v = vapour pressure obtained from Fig. 8. corresponding to the temperature at which the moist air would be saturated,
W_v = weight of a cubic foot of water vapour obtained from Fig. 7, corresponding to the temperature at which the moist air would be saturated.

The effect of humidity on the specific heat will now be considered. The specific heat of moist air is expressed by :

$$\frac{S_a W_a + S_v W_v}{W_a + W_v},$$

where S_a = specific heat of air.
S_v = specific heat of the aqueous vapour.
W_a = weight of the dry air contained in a cubic foot of the mixture.
W_v = weight of the aqueous vapour contained in a cubic foot of the mixture.

The weight of a cubic foot of air at the standard barometric pressure is given in Fig. 9, and the weight of a cubic foot of aqueous vapour is given in Fig. 7. The specific heat of air is to be taken at the constant value of 0·242—the variation with temperature will be dealt with separately. The specific heat of water vapour may be assumed to have the constant value of 0·475—the variation with changes of temperature is slight, and can be ignored when applying the above formula.

With the worst conditions that are likely to arise in practice, either of these two effects *per se* might affect the value of the losses in the alternator, as determined by the "air-heating" method, by as much as about 3 per cent. As already explained, however, the one effect tends to cancel the other and the net result is as shown in Fig. 10. It will be seen that with the worst case that is likely to arise, the correction

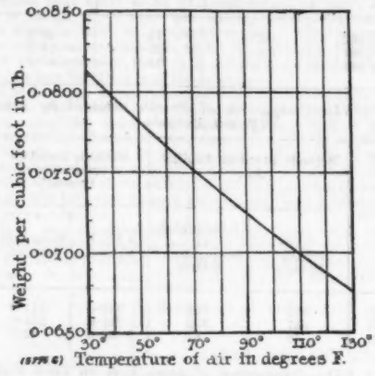


FIG. 9.—Curve showing the weight of a cubic foot of dry air at various temperatures. (Barometer: 29·92 in. of mercury.)

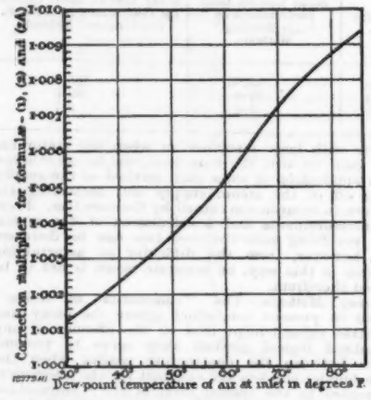


FIG. 10.—Correction in respect of variation of air density and specific heat with humidity. (This correction may be ignored for commercial work, and is not taken into account in any of the formulæ.)

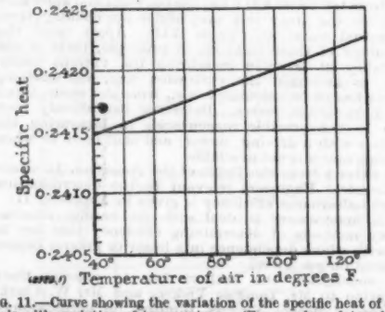


FIG. 11.—Curve showing the variation of the specific heat of dry air with variation of temperature. (From values determined by Mr. W. F. G. Swann.)

is sufficiently small to warrant it being neglected for commercial work. The final formulæ, (2) and (2A), for determining the losses by the "air-heating" method therefore do not include any correction for the effect of humidity.

Correction 4. *Effect of Temperature on Specific Heat.*—A very careful investigation made by Mr. W. F. G. Swann* showed that the specific heat of air varies very little with increase of temperature. The result of Mr. Swann's investigation is given in Fig. 11, from which it will be seen that between 60 deg. and 100 deg. F. the specific heat increases by only 0·145 per cent. If the temperature of the air leaving the alternator were as high as 140 deg. F. instead of the assumed condition of 100 deg. F., the error due to the change in the specific heat would be little more than one-fourth of 1 per cent. It is therefore quite unnecessary to make correction in respect of the variation of the specific heat.

Correction 5. *Effect of Heat Dissipated from the Stator Frame.*—To ascertain the heat energy that is dissipated from the external surface of a turbo-alternator, a careful test was made with a 5,000-kw., 3,000-r.p.m. machine. With the rotor at rest and the air inlets and outlets closed, a direct current was passed through the stator winding. When the temperature rise of the external surface reached a steady value it was found that the heat energy being dissipated was 0·006 watt per inch of surface per degree rise (Fahrenheit). Neglecting a correction for radiation would give an error in the average case of about 1½ per cent. on the losses determined by the "air-heating" method. Although this error is small, it is practically constant and the necessary correction is easily made. The formulæ in their final form, (2) and (2A), include this correction.

Minor Causes of Error.—There will be a certain tendency for the air entering the alternator to absorb heat conducted through the shaft from the bearings. Further, the small loss in the slip rings will not be measured, since they are exterior to the alternator. It is obvious that the errors introduced as a consequence of these minor matters will be infinitesimal in degree particularly as the error introduced by the tendency for heat to flow from the bearings into the alternator is offset by the slip-ring loss that is not measured.

APPENDIX II.

EXTRACT FROM THE RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.*

422. In the case of machinery two efficiencies are recognised, conventional efficiency and directly-measured efficiency. Unless otherwise specified, the conventional efficiency is to be employed.

423. Conventional efficiency of machinery is the ratio of the output to the sum of the output and losses; or of the input minus the losses to the input; when, in either case, conventional values are assigned to one or more of these losses. The need for assigning conventional values to certain losses, arises from the fact that some of the losses in electrical machinery are practically indeterminable, and must, in many cases, either be approximated by an approved method of test, or else values recommended by the Institute and designated "conventional" values shall be employed for them in arriving at the "conventional efficiency."

441. Losses to be taken into account in synchronous motors and generators.

Core losses—see Rule 452.

$I^2 R$ loss in all windings, based upon rated k.v.a. and power factor.

Stray load losses.—In approximating these losses the method described in Rule 458 shall be employed.

Friction of bearings and windage.

452. *Core Loss.*—The machine is driven from an independent motor, the difference in output of which is determined when the machine is unexcited and when it is excited to give the terminal voltage corrected for the resistance drop only. (This rule has been paraphrased.)

458. *Stray Load Losses in Synchronous Generators and Motors.*—These include iron losses, and eddy-current losses in the copper, due to fluxes varying with load and also to saturation. Stray load losses are to be determined by operating the machine on short circuit and at rated-load current. This, after deducting the windage and friction and $I^2 R$ loss, gives the stray load loss for polyphase generators and motors. These losses in single-phase machines are large; but the Institute is not yet prepared to specify a method for measuring them.

BRITISH SCIENTIFIC PRODUCTS EXHIBITION, 1919.—The British Scientific Products Exhibition, 1919, will be held at the Central Hall, Westminster, during the month of July. Now that many inventions can be shown which could not be put before the public during the war, there is every prospect that this year's exhibition will be even more successful than its predecessors. The objects of the exhibition will be to illustrate recent progress in British science and invention and to help the establishment and development of new British industries. The exhibition will include sections dealing with Chemistry, Metallurgy, Physics, Agriculture and Foods, Mechanical and Electrical Engineering, Education, Paper, Illustration and Typography, Medicine and Surgery, Fuels, Aircraft and Textiles. Firms desirous of exhibiting are invited to communicate with the Organising Secretary, Mr. F. S. Spiers, 82, Victoria-street, London, S.W. 1.

THE ALLOTROPIC TRANSFORMATION OF NICKEL.—Nickel becomes unmagnetic at about 350 deg. C., and this transformation is associated with changes in the electric resistance and in other properties, also probably in length, though not in the form of crystallisation as to which allotropic modifications of other metals frequently differ. The change in length had so far not been actually established, but Professor Jänecke (*Zeitschrift für Angewandte Chemie*—November 26, 1918, page 229) has succeeded in demonstrating it with the aid of a testing machine. He placed the cylindrical specimen—45 cm. in height—between two pressure plates, kept lower plate fixed, and observed the movement of the upper plate when the specimen was heated by means of an electric furnace surrounding it; readings could be taken within 0·007 mm. Temperatures were determined with the help of a thermocouple of gold and constantin. The expansion curve consisted of two straight lines, meeting near 350 deg. C. at an obtuse angle, above that temperature the rate of expansion was more rapid. A jump of about 0·01 mm. was observed between 347 deg. C. and 356 deg. C., and a rod of nickel 5 m. long should, in passing from Ni α into Ni β increase in length by about 1 mm. The method is recommended for observing both gradual and sudden transformation.

* Philosophical Transactions of the Royal Society, vol. ccxa, page 230.

* Transactions of the American Institute of Electrical Engineers, 1916, vol. xxxv, page 1559.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

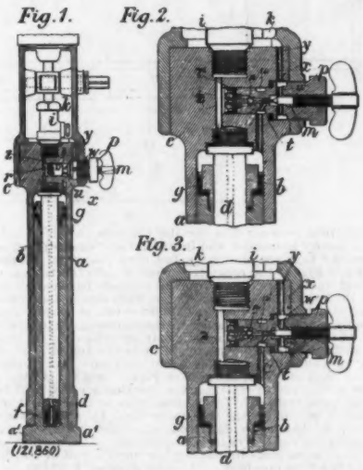
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any grounds mentioned in the Act.

LIFTING AND HAULING APPLIANCES.

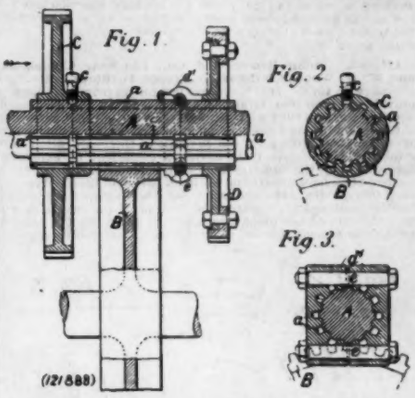
121,860. Tangyes, Limited, Smethwick, and E. Johnson, Bilston. Hydraulic Lifting Jacks. (5 *Figs.*) February 27, 1918.—The invention consists of improvements in self-contained hydraulic lifting jacks. *a* is the primary ram in one with the base *a*1 of the jack, the ram *a* being hollow through nearly the whole of its length and constituting a secondary hydraulic cylinder for the accommodation of the secondary ram *b*. The ram *b* is screwed to the body *c* so as to hang therefrom and project into the cylinder *a*. The ram *b* has an axial water-way *d* extending from end to end of the same, the water-way being continued through the screw by which the cup-leather piston *f* is fixed on the bottom end of the ram *b*. To the upper end of the ram *a*, a cup-leather piston *g* is fixed, through which the ram *b* works. Means are combined with the arrangement described for controlling the flow of the water, which is forced by the pump *i* on the working of the jack from the cistern *k* to the hydraulic cylinders, so that the whole of the water may be delivered to the cylinder *a* and thereby effect a quick movement of the ram *b* and body *c* and cylinder *c*1, or delivered partly to the cylinder *a* and partly to the cylinder *c*1. The means for controlling the direction of the water which is pumped from the cistern *k* on the working of the pump *i*, consists of the special construction and arrangement of valves comprising a stop valve *m* and inner spring pressed valve *n* both fitted in a valve body *p*, which is screwed into a radial opening in the body of the jack. The valve body *p* has a larger diameter at its outer end than at its inner end, and attached to the inner end is a cup-leather washer *r* to ensure a watertight fitting of the valve body *p* in



the opening in which it is arranged. The valve *n* is opened against the pressure of its spring by an extension on the stop valve *m* when the stop valve is fully closed as shown in Fig. 3. *t* are holes, the outer ends of which open into an annular groove *u* in the body *p*. The groove *u* coincides with a passage *v* opening into the cylinder *c*1. *w* are radial holes in the valve body *p* opening into an annular groove *x*, which coincides with a passage *v* opening into the water cistern *k*. When the stop valve *m* is opened the spring-pressed valve *n* is closed, as shown in Fig. 2, and consequently the water pumped from the cistern *k* on the working of the handle of the jack is directed by the passage *z* in the body *c* and axial water-way *d* in the ram *b* wholly into the cylinder *a*. At the same time water is permitted to flow freely from the cistern *k* through the passage *y*, annular groove *x*, radial holes *w* into the interior of the valve body *p*, then through the radial holes *t* into the annular groove *u* coinciding with the passage *v* leading to the cylinder *c*1. The high-speed ram *b*, primary cylinder *c*1 and parts attached thereto are consequently lifted at quick speed. On the closing of the stop valve *m*, the extension of this valve effects the opening of the valve against the action of its spring and the stop valve *m* seats itself in the end of the smaller hole in the tubular body *p* between the two series of radial holes *t*, *w*, and consequently the free passage of water from the cistern *k* to the cylinder *c*1 is prevented, and on the working of the pump *i* the water forced thereby into the passage *z* flows partly through or past the valve *n* and by the radial holes *t* and passage *v* to the cylinder *c*1, and partly by the passage *d* into the cylinder *a* and the head *l* of the jack is lifted at the normal or slow speed. (*Accepted January* 15, 1919.)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

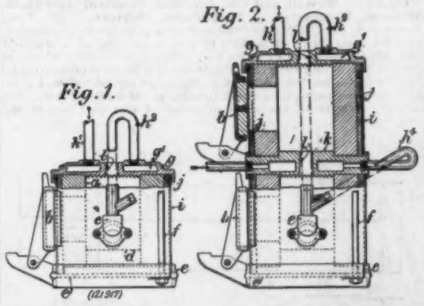
121,888. The Austin Motor Company, Limited, Northfield, Birmingham, and Sir H. Austin, Northfield, Birmingham. Gear Shafts and Wheels. (3 *Figs.*) April 5, 1918.—This invention relates to shafts on which gear teeth are cut through which power is to be transmitted to or from wheels which have axes parallel with the shafts. According to this invention, gear teeth of such shafts are made to extend along such length of the shaft as to answer the purpose also as splines for wheels which are to be carried by the shaft and the wheels each have grooves cut in the interior surface of the nave thereof to allow it to be slidden along the teeth of the shaft into the required position. Teeth *a*, which are cut into the metal of the shaft A, run such length thereof, as shown, that the middle portions of them mesh with teeth of a wheel B, and the portions to the left hand answer as splines to a wheel C through the nave of which grooves have been cut which are the counterpart of the splines, and the portions to the right hand as splines to a wheel D through the nave of which grooves have also been cut which are the counterpart of the teeth. The portion of the shaft



within which the teeth *a* are cut is shown as of sufficiently larger diameter than the ends *a*1 of the shaft to allow for the teeth *a* to be cut clear through from one of their ends to the other. the wheel C is fixed by a set-pins. The wheel D has an extension of the nave, which is split at opposite sides, and through the lugs *d*1 of the split sides are passed bolts *e*, the middles of which pass within an intermittent groove which has been formed by cutting out a number of gaps or notches in the teeth *a*. (*Accepted January* 15, 1919.)

MINING, METALLURGY, AND METAL WORKING.

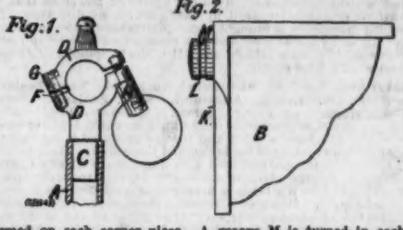
121,917. J. M. Wallwin, Warwick. Gas-Heated Furnaces or Muffles. (2 *Figs.*) June 27, 1918.—This invention relates to gas-heated furnaces or muffles as used for treating metals. *a* is the tubular body part of refractory material formed with an opening giving access to its interior, and normally closed by the door *b*. In such body part is also formed an opening to admit the gasburner *c*. A flanged blank of refractory material *d* is fitted in the lower open end of the part *a*, and rests upon the web *a*1 of the metal flange *a*. The latter, which constitutes a base upon which the furnace rests, is provided with ears to accommodate the through bolts *f* by means of which the parts, when assembled, are clamped together. The top of the body part *a* is provided with an iron cover *g*, having the hollow chamber *g*1 cast therein, said chamber being provided with inlet and outlet pipes A1, A2, respectively. The cover is recessed to accommodate the tubular body, together with the outer metal



casing *i*, and intermediate silicate or cotton packing *j*, and is also provided with snugs or ears to receive the through bolts *f*. In practice, the inlet pipe A1 is coupled to the gas supply which it is desired to pre-heat, and said gas, after being raised to the desired temperature in the chamber *g*1, passes via the outlet pipe A2 to the gas inlet branch of the burner *c*. The furnace shown in Fig. 2 comprises two tubular body parts, which are separated by an intermediate dividing blank *k* made hollow and provided with inlet and outlet pipes A3, A4. When both the cap *g* and the blank *k* are made hollow the pipe A1 will be connected to, say, the air supply, and the pipe A3 to the gas supply, whilst the pipes A2 and *h*4 will be connected to the air inlet and gas inlet branches respectively of the burner, as shown by the broken lines. With the passage *l* for the products of combustion central to the preheating chamber, the air or gas is baffled, and thus effectively heated in passing from the inlet to the outlet pipe. (*Accepted January* 15, 1919.)

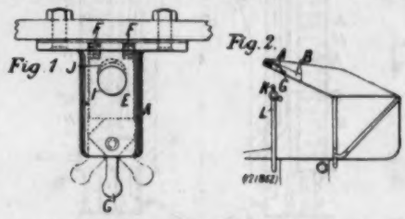
MOTOR ROAD VEHICLES.

121,545. R. W. Maudsley, Foleshill, Coventry, and The Standard Motor Company, Limited, Foleshill, Coventry. Wind Screens. (3 *Figs.*) February 18, 1918.—This invention relates to joints for the wind screens of motor vehicles. According to this invention, a joint is characterised in that each bearing is initially formed as a single piece, which is then bored to receive the journal, divided by a saw cut and provided with a packing-piece or shim to lie between the divided parts and engage by a projection formed upon it, a co-operating circumferential groove formed in the journal which the bearing supports, means (for example, screws) being provided to unite the divided parts of the bearing and cause them to grip the said journal. A is the upper portion of a supporting pillar, one of which is located adjacent each end of the wind screen B. A socket C on the lower half of a divided bearing D is adapted to fit in the top of each pillar A. The bearings are formed in the first place as single-piece stampings bored to receive the journals, and each bearing is then divided by a saw-cut. A packing-piece F, equal in thickness to the saw-cut, is then interposed between the bearing halves on one side of the bore, and a screw G holds together the halves and the packing-piece. A screw H on the other side enables the bearing to be clamped tightly on its journal. The screen B is provided with channelled corner pieces K at each end, and journals L are



formed on each corner piece. A groove M is turned in each journal, and a projection on the packing-piece F is adapted to engage in the groove so as to prevent movement of the bearing along the axis of the journal. (*Accepted December* 31, 1918.)

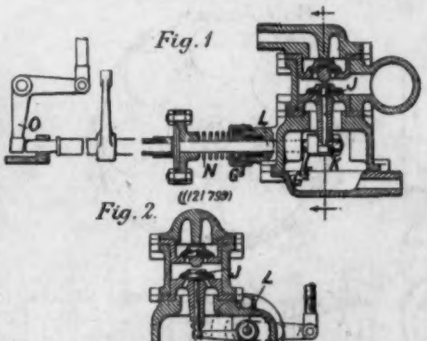
121,862. R. W. Maudsley, Coventry, and The Standard Motor Company, Limited, Coventry. Vehicle Hoods. (4 *Figs.*) March 1, 1918.—This invention relates to fastening devices for vehicle hoods. In a known type of fastening device, a cam formed on the end face of a rotatable member to bear upon the bolt, is employed to release the latter from engagement with the headed stud. According to the present invention, a fastening device of the type referred to is characterised in that the releasing device is in the form of a hand-operable lever pivoted intermediate of its ends to the lock casing, one arm of which lever bears upon the bolt and constitutes the releasing cam. A lock casing A is connected to the front bow B of the cape cart hood. A bolt E is slidable endwise in the casing, and



is pressed in one direction by springs F, and in the other direction is adjustable by a hand lever G. A hole I is provided through the casing, and a hole J with an inclined edge in the bolt E is pushed against the pressure of the springs F into alignment with the hole I by the action of the lever G when moved to its mid-position. When the holes are in alignment, the lock casing can be pressed on to a headed stud K on the wind screen L, and then if the hand lever G is rocked into either of the positions shown in chain lines in Fig. 1, the hole J is moved by the pressure of the springs F out of alignment with the hole I and the inclined edge of the hole J is caused to engage the neck of the headed stud, thereby securing the lock casing to the stud. (*Accepted January* 15, 1919.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

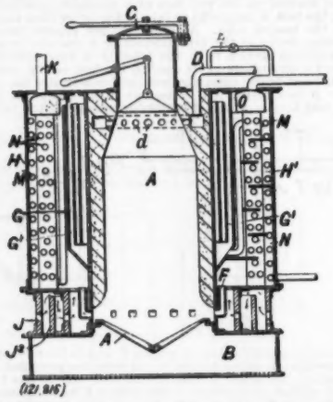
121,799. T. Clarkson, Galleywood, Chelmsford. Feed-Water Supply Apparatus. (3 *Figs.*) December 31, 1917.—This invention relates to feed-water supply apparatus for steam generators, more particularly mechanism of the type in which the movements of a float regulator are utilised to regulate the water delivered by the feed pump by controlling the movement of the suction valve of the pump. According to this invention, the pump suction valve J, which is normally free to be lifted by the suction and afterwards permitted to fall on to its seat, is adapted to be lifted and held off its seat, so as to prevent delivery of the water drawn into the pump, by a lever K mounted on a shaft L which is rocked by the movements of a float, which result from variations in the level of the water in the generator, while the rock shaft L has imparted to it a constant reciprocating



movement in the direction of its axis, whereby the shaft is kept free so that the application of only a small force is necessary to rock it. One end of the rock shaft is carried by a stuffing box G3, through which it passes into a chamber G2, whence the water is drawn past the suction valve J, and the reciprocating motion of the rock shaft obviates any tendency for this stuffing-box to offer such resistance to the rotation of the shaft as will prevent the float movements being imparted through the shaft to the suction valve of the pump. On the end of the rock shaft within the pump chamber is a lever K, which can so act on the suction valve as to lift and support this valve off its seat and retain it so until the water level in the generator has fallen sufficiently to cause the float to move and permit the suction valve again to seat itself. While this valve is lifted the water drawn in by the pump is merely forced back again to the tank

and is not delivered to the generator. The necessary reciprocating movements may be imparted to the rock shaft in various ways, but conveniently by a lever O which bears against the end of the rock shaft, hardened bearing surfaces between these parts being provided. This lever is moved by means of suitable mechanism from some convenient source of power so that the shaft is constantly pushed by the lever in one direction. The return movement is brought about preferably by the action of a spring N. Various lever and link connections may be employed between the rock shaft and the float spindle. (*Accepted January* 15, 1919.)

121,816. H. A. Nicholson, Auckland, New Zealand, and E. A. Craig, Auckland, New Zealand. Steam Generators. (2 *Figs.*) January 2, 1918.—This invention relates to steam generators of the kind in which a gas producer is combined within a boiler and the gas produced is led into the combustion chamber of the boiler, and there fired. The generator is formed by the gas producer A having a grate A1 and a closed ash pit B, and the charging means C. Air is introduced through the pipe D and the inlets *d* arranged around the upper end of the generator. Steam is introduced through the pipe E, which enters the air admission pipe D. The gas produced passes from the bottom of the producer through ducts F, which are arranged to lead upward on the outside of the producer. The producer is surrounded by a jacket G enclosing a space G1, and outside this jacket is the outer shell H of the generator, which is so disposed as to provide a clear space H1 all round, and which space forms the combustion chamber of the generator. The gas ducts F lead into the bottom of the combustion chamber, and air is also admitted to the bottom of this chamber through air apertures J.



The air entering through the apertures J is heated by passing over the surface of a baffle J2, which is kept heated by the heat from the producer, so that when the heated air mingles with the hot gas the mixture spontaneously combusts and the heat passes up through the combustion chamber H1 and out through a number of vents K opening from the top thereof. Means are placed within the combustion chamber for the production of steam through the combustion of the gas therein. These means consist of a pipe coil M that extends around the inside of the shell H from the bottom to the top thereof and the bottom end of which is connected to the water supply, the jacket space G1, previously described as surrounding the producer, and into the bottom of which the top end of the coil M is led, and a series of water tubes N extending horizontally through the combustion chamber and connected with the top of the space G1 and with a steam chamber O in the top of the combustion chamber. The feed water passing up through the coil M is heated, and passes into the jacket space G1, in which it becomes subject to the heat radiating from the producer. The water will thus be practically converted into steam in its passage through this space, and will pass out into the tubes N. (*Accepted January* 15, 1919.)

121,891. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, L. J. Le Mesurier, Newcastle-on-Tyne, and N. Legge, Newcastle-on-Tyne.

Fig. 1.

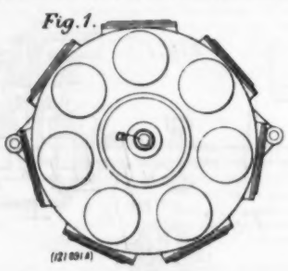
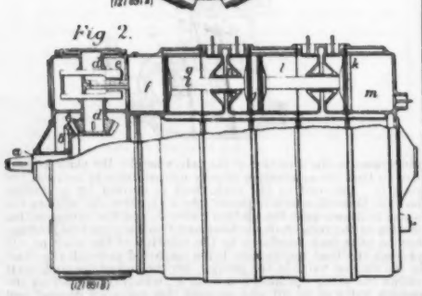


Fig 2.



Reciprocating Engines. (2 *Figs.*) April 11, 1918.—This invention relates to improvements in reciprocating engines of the type in which a number of cylinders is arranged in co-axial groups around, and having their axes parallel or substantially so, to a central main or propelling shaft. According to this invention, a number of sets of cylinders is employed, each set comprising three or more co-axial cylinders driving a crankshaft, the various crankshafts being connected to the main shaft through bevel gear. *a* is the main shaft provided with a bevel wheel *b*, with which mesh seven bevel wheels *c*, each of which is fast on the crankshaft *d* of one set of cylinders, *e* is a connecting rod connecting the crankshaft *d* to a piston *f* working in the first cylinder *g*; coupled to this piston by a rod *i* are two other pistons *j*, *k*, working in cylinders *l*, *m*, which are suitably water-jacketed in the case of an internal-combustion engine, and *n*, *n*, are cylinder heads interposed between the cylinders *g*, *l*, *m*. (*Accepted January* 15, 1919.)

121,392. John Brown and Co., Limited, Clydebank, and W. H. Wood, Clydebank. Steam Turbines. (2 *Figs.*) February 6, 1918.—This invention has for its primary object to provide an improved arrangement for centring the diaphragm sleeve of a steam turbine which will allow for unequal expansion of the diaphragm and casing and yet will involve minimum leakage of steam. According to the invention, there are fitted substantially radial rods 1, 11 having a coefficient of expansion approximately the same as that of the metal of the casing 2, one end of each rod bearing on the inner part 31 of the diaphragm 3 near the spindle, while the other end bears against the casing. The inclined rods 1, towards the bottom of the casing 2, will take the load of the diaphragm and will determine the relative vertical movement thereof, while the rods 11, placed in approxi-

Fig. 1.

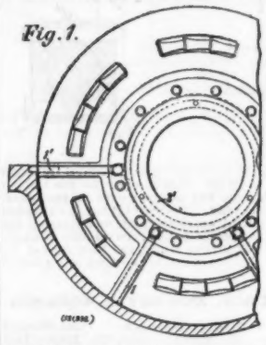
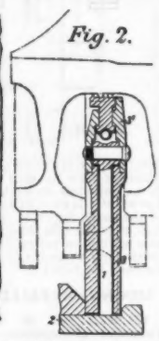
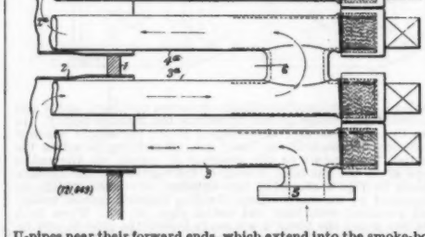


Fig. 2.



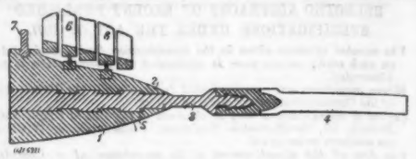
mately horizontal position, will serve to minimise any side movement of the diaphragm centre. The outer ends of the rods 11 may be shaped so as to accommodate any small differences in expansion between the casing 2 and the internal centring parts, being extended into the casing 2 with the object of forming a stop to prevent rotation of the diaphragm in the casing. Where the casing 2 is of cast-iron or steel and the diaphragm 3 of copper alloy, the inner part 31 of the diaphragm may be formed of metal having a co-efficient of expansion approximately the same as that of the casing, and to this inner part 31 of the diaphragm, constituted in the present instance by metallic plates, the inner ends of the rods 1 may be attached by screw pins, provision being made to permit of the free relative expansion of the other parts of the diaphragm. (*Accepted December* 30, 1918.)

121,649. Howell and Co., Limited, Sheffield, and G. H. Willans, Gloucester. Feed-Water Heaters. (3 *Figs.*) January 8, 1918.—This invention relates principally to elements of the U-loop type. A heating element consisting of a plurality of U-pipes connected in series and adapted to be inserted one in each of two or more enlarged flue tubes of a boiler is characterised by the fact that the adjacent U-pipes are connected and communicate by means of a short tubular piece secured, preferably welded, directly to the sides of adjacent legs or pipes of the



U-pipes near their forward ends, which extend into the smoke-box of the boiler. 1 is the smoke-box tube plate of a locomotive boiler. The pipes 3, 3a extend into the smoke-tube 2 and the pipes 4 and 4a extend into the smoke-tube 2a. 5 is a flange connection forming the inlet to the heating element, and 7 is a similar flanged connection forming the outlet. 6 is a short tubular piece suitably welded on to the sides of, and forming circulating connection between the pipes 3a and 4a. The ends of the pipes 3, 3a, and 4, 4a are externally screw-threaded, and are adapted to receive internally-threaded screw caps. (*Accepted January* 8, 1919.)

121,692. The Brush Electrical Engineering Company, Limited, London (*Aktiebolaget Ljungströms Ångturbin, Stockholm, Sweden*). **Turbine Discs.** (1 *Fig.*) May 8, 1918.—In the manufacture of large turbine discs for high-speed turbines, difficulties arise in hardening the disc in order to obtain the same strength in the inner and outer parts thereof. It has therefore been proposed to build up turbine discs of a number of separate interconnected elements to relieve the strains and tensions due to rapid rotation, and the present invention relates to a turbine disc of this kind in which three members, viz., a complete intermediate disc and two complete side discs are connected together by means of a number of flanges or grooves having a dovetailed form, said flanges or grooves being provided in the surfaces of the discs at different radial distances and fitting one another when the side discs are shrunk on to the intermediate disc. In such an arrangement, the side discs and the intermediate discs will act conjointly to resist the stresses caused by rotation. In manufacturing large turbine discs said arrangement also allows of obtaining such dimensions as may be suitable for forging and hardening. On the intermediate member 3 of the turbine disc, the radial blades 4 are arranged. By means of the dovetailed grooves 5 the outer members or the side discs 1, 2 have been



shrunk on to the intermediate disc 3, thus forming, together with the latter, a rigid construction, so that tensions caused in the intermediate disc 3, owing to rotation, will be transmitted to the side discs 1, 2, and resisted thereby. 6, 7 designate axial blades which in some forms of turbine may be connected to one of the outer discs. (*Accepted January* 8, 1919.)

MISCELLANEOUS.

121,717. H. H. Hodkin, Sheffield. Building Concrete Work. (4 *Figs.*) October 16, 1918.—This invention relates to shuttering for use in building concrete work, and pertains more particularly to the type of appliances in which the sides of the shuttering forming the mould for the concrete can be turned upwards about a fixed point when it is desired to superimpose another layer of concrete on one already set. According to this invention, the parallel shutterings are made as rigid structures for any desired depth, and as shown in Fig. 1, each consists of a centre *a* encased in galvanised metal sheeting *b*. At the top and bottom of the centre *a*, and within the casing *b*, are round bars *c*, the casing having correspondingly rounded edges where it passes over the same. The two parallel shutterings are tied together at the top and bottom by wires *d*, which pass over and under the top and bottom edges of the casing *b*, then through holes formed in same, and partly around the bars *c*, being tied together about the centre of the trough formed by the shuttering, and the free ends being turned upward and downwards respec-

Fig. 1. *Fig. 2*

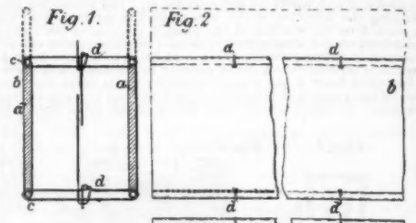
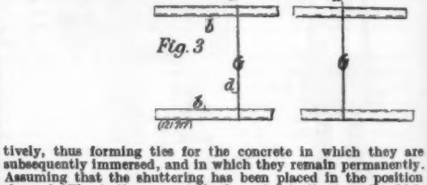
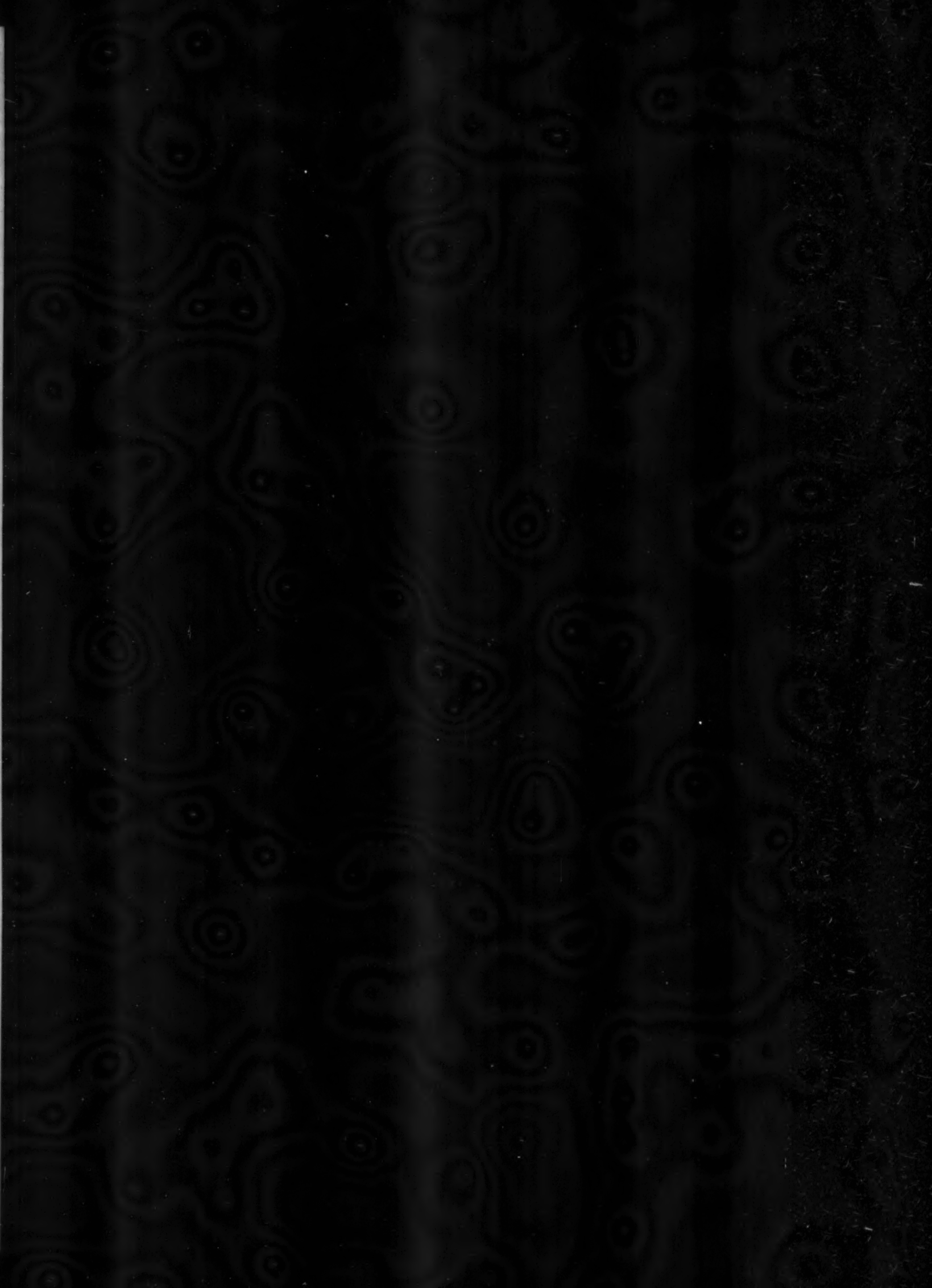


Fig. 3



tively, thus forming ties for the concrete in which they are subsequently immersed, and in which they remain permanently. Assuming that the shuttering has been placed in the position shown in Fig. 1, the concrete is charged into the trough, which is filled up to the brim. After the concrete has been allowed to dry, the lower wires *d* are severed on each side of the shuttering. When this has been done, each shutter can be turned upwards about a centre corresponding to the centre of the upper bar *c*, and as the upper wires *d* are firmly embedded in the concrete the shutters can be moved round upon the bowed ends of the said wires, until they assume a vertical position as indicated in dotted lines in the upper part of Figs. 1 and 2. As the lower edges of the shutters in their new position are still held by one of the wires embedded in the first layer of concrete, it is only necessary to connect the two upper edges by wires in a similar manner to that before described, when the shuttering is ready to receive a further charge of concrete. This raising of the shutters can be done indefinitely, or until a wall of the desired height has been obtained. (*Accepted January* 8, 1919.)

"MECHANICAL WORLD" YEAR BOOK.—We have recently received a copy of this well-known publication for the current year. Its contents, which are doubtless familiar to most of our readers, include sections on steam engines and boilers, internal-combustion engines, properties of metals, structural iron and steel, and power transmission; and all these, and many other subjects, are dealt with in a practical manner calculated to be of considerable service to mechanical engineers. The information given is kept well up to date, and the high standard reached in previous years is fully maintained. The price of the publication, bound in red cloth covers, is 2s. net, and it is published by Messrs. Emmott and Co., Limited, of 65, King-street, Manchester, and 20, Bedford-street, London, W.C. 2.

L'ANNUAIRE DU BUREAU DES LONGITUDES POUR 1919.—A copy of this publication, which has appeared regularly since 1796, has recently come to hand. Included in its small compass is a mass of information of interest to astronomers and navigators, as well as to the general public, such as the relative positions of the heavenly bodies for each day of the year; the form, dimensions, weight and density of the earth; magnetic elements, weights and measures, statistics of population, interest and annuity tables, and the calendars of all countries of the world. An article by Monsieur P. Appell on the equilibrium of a rotary liquid, and another by Monsieur Maurice Hamy on the determination of the diameters of heavenly bodies by interference, are worthy of special mention. The book is published by M.M. Gauthier-Villars and Cie., 55, Quai des Grands-Augustins, Paris, and its price is 3 francs net.